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SUCCESSFUL EXPERIMENT

THE nationalised structure of the gas industry in Wales is so different from that in the other 11 areas and so similar, save in ownership and closer co-operation, to the old set-up that it is not without interest to see what progress has been made in the past 10 months and what are the future prospects. The area board, with its comparatively very small number of principal officers, supersedes the company directors and the municipal gas committees, but there is no divisional administration, as such.

The problems that faced the Wales Gas Board from the outset were vastly different from those in England and Scotland. With its total annual sales—according to the 1947 statistics issued last year by the Ministry of Fuel and Power—of only 12,934 mill. cu.ft. (58,542,852 therms) against the next smallest area (the Southern) with 21,563 mill. cu.ft. (102,044,256 therms) and the largest of all, yet smallest in area (North Thames), with 62,293 mill. cu.ft. (320,377,075 therms), Wales was clearly not a suitable area to be administered on the divisional and district principles found necessary and successful in the other areas. There are undoubtedly great potentialities for expansion, severely limited though they undoubtedly are by the geographical characteristics of the country, and the group committee system shows every promise of being the strongest and soundest line of approach to the tasks that lie immediately ahead, as well as the longer term developments of future years.

The separate undertakings have been gathered into convenient groups, each with a chairman and convener who have no more power than to co-ordinate and co-operate and to act as intermediary between the board and the undertaking. The chairmen and conveners meet periodically for what may be termed a staff college course, and some exceedingly useful work is done at those meetings.

Through the kindness of Mr. T. Mervyn Jones, Chairman of the board, whose pride in the soundness of the scheme is exceeded by his modesty in refusing to be dogmatic about it, we have, at our own request, had a glimpse at the notes of the most recent of these meetings, at which Mr. C. B. Mawer, the Secretary, pointed out that to give a group chairman dictatorial powers would destroy the whole idea and be tantamount to the adoption of divisional control, which would bring with it a more restrictive control from area level. The group chairman's position *vis-à-vis* his colleagues on the group committee is similar in every way to that of the Chairman of the area board *vis-à-vis* his colleagues. It is the duty of the group chairman to obtain the freely expressed and discussed collective views of the members and to take such action between meetings as may seem to him to be necessary and desirable. At all times he is expected to place his experienced service and mutual assistance at the disposal of his colleagues. Should an emergency arise it is his duty to advise headquarters immediately. Actual authority of group committees to take upon themselves the expenditure of money and approval of schemes has not been precisely defined. It has been left to the good sense of the committees and so far in the view of the board the committees have not exceeded their powers.

Steps have been taken to assist in the efficient running of the groups through the stationing at strategic points of specialists in various fields, and functional (area) committees have been brought into being—to a large extent to fill the place of the district committees of the former British Gas Council—to deal with domestic and industrial development, coal and oil, coke and by-products, industrial relations, Parliamentary, legal and rating, and education, comprising members of the board and representative managers. Stress has been laid on the training of young men who will be well equipped to take increasingly important appointments if the board is to rely on promotion from within the Wales gas industry. Many valuable suggestions have been made with regard to pooling of transport within groups and similar matters, and we are especially pleased to note that officers at all levels are being encouraged to keep the Press informed of their activities, and that only on questions affecting major policy is there insistence on reference to headquarters before communication with the Press. The industrial relations officer has pointed out that redundancy may arise in certain cases where carbonising plant ceases to operate on the introduction of bulk supply schemes, and group committees faced with such a situation have been asked to give attention to the need to offer alternative employment.

Group chairmen and conveners have been told by Mr. S. L. Wright, Area Gas Engineer, that the preparation of

an accurate monthly summary of results has involved much more work than anticipated owing to inaccuracies and omissions. Notes have been issued on the matters that most frequently arise for attention. Standards of quality and supply have been set as ideals towards which the industry should direct its endeavours, and some instrumentation and preliminary work has been conducted to that end. An important communication discussed at the last meeting was that on accountancy by Mr. T. A. Morgan, Chief Accountant to the Board, who pointed out that the general programme which it is intended to follow in progressing towards the full accountancy system ultimately to be adopted provides for the establishment of detailed and accurate prime records, the setting up of a uniform system of main and sub-heads of account, standard returns for all undertakings, and the building up of a budgetary control system. Our old friend, Mr. W. Clark Jackson, dealing with coal problems, said that amended coal prices represented an increase of £40,000 in the area coal bill. With the co-operation of engineers and managers tests had been carried out and coal deliveries in South Wales had been so far re-allocated as to indicate a saving in delivered price over a full year of about £13,400; corresponding re-allocations in North Wales promise a saving of £3,200.

Mr. W. H. Tarn, the area Industrial Gas Engineer, has found difficulty in obtaining suitably qualified engineers to deal with the industrial side, and it has been decided that industrial gas engineers shall in future be trained around the existing staff as and when junior engineers are required. The complicated question of industrial gas tariffs is being tackled, and all undertakings are being asked to contribute something to the quarterly reports of the Wales Industrial Gas Development Committee, whose Chairman is Alderman G. F. Hamer, Chairman of the Gas Consultative Council.

ALTERNATIVES

THE distribution systems of many of the undertakings now vested in the Wales Gas Board are unsatisfactory. Pressures are uneven and at times of peak load in many cases quite inadequate. Excessive pressures are too common, and Mr. W. T. Hird reports that a lot of work will be necessary before all consumers can be assured of an equal level of good service. No fewer than 32 undertakings made less than 15 mill. cu.ft. of gas in 1948, and a further 30 undertakings each made between 15 and 30 mill. High cost of production in many small works, and still more the high cost of new plant to replace worn out units or to increase supplies is a matter for serious concern, reports Mr. W. R. Branson, Development Engineer. In some cases bulk supply will present the best solution, but there are probably 20 or more undertakings making less than 15 mill. cu.ft. per annum unlikely to be economic to supply in bulk. Some reduction in production costs in these works might be effected with the adoption of economies in operation, such as electrification of exhausting and boosting plant. The board is considering other less conventional means of gas manufacture which might enable cheaper gas to be produced; these include the distribution of a butane/air mixture in lieu of coal gas, and the gasification of oil. Use of transportable plant while resetting is in progress is also under consideration as a means of reducing the cost of standby plant.

An account was given of the progress that was being made with the gas grids in the eastern and western portions of South Wales and it was reported that in connection with the co-ordination of gas supply in North Wales the Board had decided to proceed, as a first step, with the construction of a complete new works at Wrexham, already planned by Mr. J. F. Lloyd before vesting day, but on a new site, and to afford a bulk supply from the works to the undertakings between Llangollen and Connah's Quay, and possibly also to connect with the Holywell and Flint undertaking. Construction of new carbonising units of large size is now taking five to six years from the date of ordering, and this makes forward planning very necessary if the rapidly expanding demand for gas in Wales is to be overtaken. The effect of Government decisions on capital expenditure by the board during the next few years is not yet known. It may be that some of the developments contemplated will be retarded as a consequence of restrictions on capital expenditure.

Altogether the outlook in Wales, although beset with difficulties beyond the control of the board or its employees, is bright and after nearly 12 months' working there seems to be no reason to question the optimism of those who first suggested the experiment of the group committee system.

THE SCOTTISH GAS BOARD

ON February 25 the Eastern and Western Districts of the Scottish Junior Gas Association, at a joint meeting at Falkirk, had the good fortune to be addressed by the Chairman of the Scottish Gas Board, Sir Andrew Clow, and we were privileged to be present to hear what was a most encouraging discourse which Sir Andrew threw open to discussion. The meeting was held in the Falkirk gas showrooms demonstration theatre and was preceded by a visit to the gasworks. The arrangements made for the meeting by Mr. W. Ewing, Engineer and Manager, were admirable and there was a large attendance of junior gas engineers from East and West Scotland. And we would add that the tone of the proceedings was pleasantly informal; certainly the Scottish juniors must have been heartened by Sir Andrew's assurance that the board had their interests very much at heart. Any other attitude would, indeed, be the reverse of farsighted; the future of the gas industry depends on the attraction to its ranks of keen and intelligent young men in a career which should offer prosperity, happiness, and usefulness. Other industries and professions are competing for young men of the type, and the supply is not abundant. On this question of encouragement we were not surprised that the matter of payment of expenses for juniors to attend association meetings should be raised, and in Scotland, with its widely scattered undertakings, such expenses assume an uncommon burden in many cases. But Sir Andrew made it clear that he wanted to encourage attendances at association meetings and that he favoured doing what was legitimate regarding expenses entailed. This brings us to a point which we

think the juniors might well contemplate, and that is whether the junior associations in general do not cram too many meetings into the sessions. One of the junior associations, for example, has the astonishing number of 22 events in its current fixture list. Is such a crowded programme really necessary or even desirable?

The theme of Sir Andrew Clow's address was how the Scottish gas area might with acumen be strengthened as a Scottish nationalised unit. He suggested in his address that several people had told him that it would be better for them to travel south to better climes. We are well aware that many Scottish gas engineers have travelled south to occupy important positions, but while referring to this influx to England Sir Andrew assured his audience that first choice for Scottish appointments would be made from Scotland itself. We believe that Sir Andrew Clow, in his quiet manner of address, pricked here and there a bubble or two of the ambitions of the Scottish Juniors, while maintaining his claim that without keen and interested youth the gas industry in Scotland would not go where it should.

The administrative qualifications of Sir Andrew are, of course, well known, and we feel that he was, through his experience, giving encouragement to development not only of the juniors but of the gas board as a whole. When we listened to Sir Andrew we sensed at once his diplomatic approach to any problem, and, as he said, the peculiar conditions of the 193 scattered undertakings in Scotland gave him something of a headache. It is quite obvious that in the Scottish area at the moment the area board as such, and the divisions, are marking time. There are, of course, very many and complicated points of administration of which Sir Andrew is well aware. A major complication exists in the Glasgow area and we trust that the Scottish Gas Board will give an explanation of the situation from time to time.

DISTRICT SECTIONS

JULY 1 is likely to be the date for the first actual conversion of a district association into a District Section of the Institution of Gas Engineers. Appropriately the first association to take the step is the Eastern District of the Southern Association of Gas Engineers and Managers, in which the change was originally suggested by Mr. H. J. Escreet during his term of office as President of the main Association and also as Chairman of the Eastern District. At a meeting of the Eastern District last week Lieut.-Colonel J. A. Gould reviewed the negotiations and reported that at a recent meeting there had been considerable discussion as to whether the Southern Association should seek to affiliate as one or as two sections and it was ultimately decided to divide East from West. Throughout the negotiations, he said, there had been some fear as to the future status of those members of the Association who had not been qualified for membership of the Institution under its existing rules, but it had been made quite clear that all existing members would be taken into some form of membership of the Institution. The Eastern District Committee—whose action was not opposed at last week's meeting—has decided to apply for affiliation as the 'Institution of Gas Engineers, London and Southern Section, incorporating the Southern Association of Gas Engineers and Managers (Eastern District)' as from July 1.

It still remains for the Western District to reach a decision, but as the President of the main Association is a Vice-President of the Institution and the two districts have worked in harmony for so long we have little doubt as to the outcome. The change will alter the character, rather than the spirit, of co-operation between the two districts, one of which, the Eastern, has 270 members compared with the 78 in the Western District.

CONSULTATIVE COUNCILLORS

A NOVEL point arose at the third quarterly meeting of the Southern Gas Consultative Council at Bournemouth last week when members were considering the date of the next meeting. The Chairman, Alderman J. W. Moore, widely experienced in local authority affairs, having served for a record period of two and a half years as Mayor of Bournemouth and being still in office as Deputy Mayor, urged some caution in fixing the date to allow time for local authorities to nominate new members in place of any who may be unfortunate enough to lose their seats in the May elections. The Gas Act does not make any specific provision for such contingencies. It neither says that any person shall represent a particular local authority nor defines the period of tenure of office, but it does say quite definitely that not less than half nor more than three quarters of the members of a consultative council shall be appointed (by the Minister) from a panel of persons nominated from *among members* of local authorities in the area by such associations as appear to the Minister to represent those authorities. The only other ban imposed under the section relating to the constitution of the consultative councils is that a chairman is disqualified if he becomes a Member of Parliament. For members of the area boards there is a regulation that tenure of office shall be for such term not exceeding five years as may be determined by the Minister, members being eligible for re-appointment. So far as consultative councils are concerned, it would appear that after every annual election (usually one-third of the members of a local council are elected annually for a period of three years) the Association of Municipal Corporations and/or any equivalent organisations representing urban and rural district councils will have to review the position in every area and call for the submission of fresh names from the individual councils for inclusion in the panel from which the Minister will make his selection. The position with regard to the members of the divisional committees within the areas is even more vague. Each consultative council has prepared its own scheme, but in most cases the scheme provides for nominations from the local authorities. While there is nothing to prevent, say, a co-operative representative from continuing to serve long after he or she chooses to leave the local co-operative society, there must inevitably be, to some extent, an annual change among those who have been, in the first place, elected at the poll to serve their fellows.

Another matter raised at the Bournemouth meeting was a complaint from a member of the council that two men from a major undertaking 40 or 50 miles away,

apparently engaged in some form of appliance census, had asked the member's wife some impertinent questions as to how she became possessed of a very nice new gas cooker they found in use in her kitchen. The Chairman, while not disputing the point that such conduct would annoy anybody, assured the council that the matter would be investigated and suggested that due allowance should be made for the ordinary weaknesses of human nature.

YOUTH IN INDUSTRY

SOME interesting facts concerning the present position and future availability of young persons for industry have been published by the Ministry of Labour in a pamphlet which is now being circulated. Prepared by the Central Youth Employment Executive, the pamphlet quotes available statistics which show that, through the low birth-rate in the 'thirties and the post-war raising of the school-leaving age, by 1955 there will be only one half the number of young persons in industry that there were in 1945. The evidence suggests that at present a high percentage of young workers are employed in middle-sized and small firms, and that a substantial majority is employed in positions for which training under apprenticeship or similar schemes is inappropriate. It is further estimated that of all the young workers who enter industry, not more than 30% are trained for skilled crafts or trades under some form of apprenticeship. The others are employed on a wide variety of jobs, many of which are repetitive in character, and few of which demand any long period of vocational training. The pamphlet thus serves a valuable purpose in emphasising yet again the serious and increasing shortage of young people for industry on the use of whom, it believes, the economic future of the country depends. Finally, in dealing with schemes of employment and training for young workers, the pamphlet urges that five 'general principles' should be followed, and defines them as good reception arrangements, avenues of progress for young workers, welfare facilities, planned practical training, and release from work for further education.

INTEGRATION

IN an address to the North Thames Gas Consultative Council last October, Mr. Michael Milne-Watson, Chairman of the North Thames Gas Board, said that the board was preparing a scheme of integration eastwards similar to the gas grid which conveyed gas right through from Beckton to the west. Connections were being made, he added, and interconnections were being developed between works hitherto separated from each other except for fringe connections laid for emergency purposes during the war. Such a policy was, of coure, in keeping with the suggestion made a month later by the Deputy-Chairman of the Gas Council, Colonel H. C. Smith, that although large-scale integration was a long way off, there was a lot that could be done immediately on a small scale. The first fruits of the North Thames Gas Board's scheme have been borne; the North Thames Consultative Council was informed at its monthly meeting on March 2 that at times of high demand for gas it had been found possible to adopt a policy of controlled transfer of gas in substantial quantities from districts where there had been a margin of capacity to others where the demand had exceeded the supply. Thus in the cold 'snap' from January 27 to 29 the Gas Light District had sent out to other districts more than 5½ mill. cu.ft. Of this total the Romford District, in the eastern section of the area of the board, had been able to accept 1½ mill. cu.ft. This was the first occasion on which Romford had been able thus to benefit, due to the fact that since vesting day connecting mains have been laid and the district's calorific value has been increased to conform with that of the adjoining Gas Light area. The fact that the board considered this development should be brought to the special notice of the consultative council is a measure of its determination to establish a consistent and uniform gas supply throughout the London area.

Diary

Mar. 10.—London and Southern Junior Gas Association: Short Paper Meeting. 'The Use of Steam Ejectors as an Aid to Dry Purification,' L. J. Collins (Luton); 'New Refractories and Insulating Materials,' E. A. K. Patrick (Watson House); 'A New Design of a High Temperature National Draught Furnace,' R. F. Hayman (Watson House); 'A Novel Application of Gas,' J. E. Cooper (De La Rue (Potterton Gas Division), Ltd.). Lecture Theatre, North Thames Gas Board, 178-180, Edgware Road, London, W.2. 7 p.m.

Mar. 11.—Scottish Junior Gas Association (Joint Meeting): 'The Role of the Institution in the Gas Industry,' J. H. Dyde, Junior Vice-President of the Institution of Gas Engineers, Deputy Chairman, Eastern Gas Board. Royal Technical College, Glasgow, 5.30 p.m.

Mar. 14.—Midland Junior Gas Association: 'Construction of Tower Purifiers.' E. Arthur, A.M.I.W. (Birmingham). Birmingham.

Mar. 15.—Yorkshire Junior Gas Association: President's Day, Bradford. Visit to Birkshall Gasworks, Bradford, 10.30 a.m.

Mar. 18.—Manchester District Junior Association of Gas Engineers: Meeting Engineers' Club, Manchester, 3 p.m. Address by C. H. Chester, O.B.E., Chairman, South Western Gas Board, President, Institution of Gas Engineers. Annual Dinner.

Mar. 20.—Eastern Gas Consultative Council: Connaught Rooms, Great Queen Street, London, W.C.2, 2 p.m.

Mar. 20.—Women's Gas Council: Executive Committee, 1 p.m. Headquarters Members' Meeting, 3 p.m. Gas Industry House.

Mar. 20-21.—Women's Gas Council: Branch Conference, Gas Industry House, 3 p.m.

The Ideal Home Exhibition, which opened at Olympia on March 7, will continue until April 1. A feature of the exhibition is the Gas Council's stand.

In our article on Tingley in the issue of the *Gas Journal* of February 22 we stated that the site levelling and demolition was carried out by Messrs. George Wimpey & Co., Ltd., whereas in fact the work was carried out by the United Kingdom Construction and Engineering Co., Ltd.

A line was accidentally omitted from our report of Mr. T. C. Finlayson's contribution to the discussion on Mr. S. K. Hawthorn's paper to the Midland Association of Gas Engineers and Managers on February 16 (*Journal*, March 1, p. 524). The final sentence (the omitted words being shown in italics) should have read:

'It might be worth placing on record that the capital cost of a modern continuous vertical retort plant provided with all amenities as above mentioned was at least 25% more *expensive than a plant would be if pre-war standards were still* acceptable. In other words, simplification in specification by the buyer was the most practical means of reducing capital costs of carbonising plant.'

The square root symbol was accidentally omitted from three lines of the manuscript of Mr. C. Whitehead's paper on 'Thermal Rating of Burner Injectors' in the *Journal* of February 15 (pp. 410-414). The paragraph headed 'Wobbe Index' should have read: 'The gas rate to an appliance through a fixed orifice varies inversely as the square root of the specific gravity of the gas; thus the thermal input will also vary inversely as the square root of the specific gravity. The thermal input varies directly as the calorific value of the gas. From these two points it is obvious that a measure of the rate of heat input is the Wobbe index, which is:

$$\frac{\text{Calorific value}}{\sqrt{\text{Specific gravity}}}.'$$

There was also a slip in the fifth paragraph of the paper, dealing with burner tests, where the word 'construction' should read 'consumptions.'

Personal

Mr. **David Jacobs,** who has been in the service of J. H. Robinson & Co. (Liverpool) Ltd., since October, 1940, has been appointed Sales Director.

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Mr. **E. Glover Clark** has been appointed sole representative of Abbott, Birks and Co., Ltd., for the North Western, North Eastern, Northern, and Scottish Gas Board areas.

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Mr. **A. E. Impey,** Deputy Chairman of Powers-Samas Accounting Machines (Sales) Ltd., has resigned. Mr. **R. Wonfor** has been appointed Managing Director.

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Mr. **S. Tomlinson Jones,** who recently left the Leek undertaking of the West Midlands Gas Board to take up the position of Engineer and Manager of the Stratford-on-Avon undertaking, has been presented with a hide music case, by his former colleagues of the North Staffordshire Division. Mr. J. E. Stanier, the Divisional Manager, in making the presentation, spoke highly of Mr. Jones's service as Engineer and Manager of the Leek undertaking, and wished him every success in his new appointment.

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Mr. **Philip J. Noel-Baker,** formerly Secretary for Commonwealth Relations, has succeeded Mr. **Hugh Gaitskell** as Minister of Fuel and Power. Mr. Gaitskell, who followed Mr. E. Shinwell as Minister of Fuel and Power in 1947, after having served as Parliamentary Secretary, is now Minister for Economic Affairs. Mr. **A. Robens** remains at the Ministry as Parliamentary Secretary. Mr. **R. Kelf-Cohen,** C.B, Under-Secretary in charge of the Gas Division, has been appointed Under-Secretary in charge of Petroleum (Home) Division, and Mr. **R. N. Quirk** has exchanged places with him.

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Mr. **Colin Smettem,** originally Assistant Secretary to the North Western Gas Board, has now been appointed Legal Officer to the Board. Mr. Smettem, who is 33, was articled in 1933 to the Town Clerk and Clerk of the Peace at Scarborough, and before joining the Board in May, 1949, was Assistant Town Clerk at Wallasey, Cheshire. In 1939 he volunteered in the ranks of the Royal Artillery, and after serving in India and Burma was demobilised in 1945 with the rank of Major.

Obituary

Mr. **Hambrook Russell-Jones,** Managing Director of A.C.E. Machinery, Ltd., died suddenly on February 22, while he was keeping a business appointment in London. He was born in Sydney, Australia, where he spent most of his early life. He won an Electrical Cadetship to the Sydney County Council and eventually became Electrical Superintendent. From Australia he took positions in various parts of the world, including America and Canada, most of them in engineering, including the Ford Motor Company, Detroit. At the outbreak of the first world war he joined the R.N.V.R. and served in various theatres of operations. On the cessation of hostilities he opened up as a consulting engineer in London where he was instrumental in designing and introducing specialised electrical engineering equipment for various trades. During this period he became interested in the design and development of builders' tower mast hoists which he undoubtedly pioneered. This led to the rapid progress of A.C.E. Machinery, Ltd. He was Managing Director of that Company for many years until his death, and his enthusiasm, genius, and foresight bore fruit in the rapid development of the company with its consequent benefits to mechanical handling practice throughout the world, particularly in the building and gas industries.

Mr. **J. Percy Plant,** J.P., Chairman and Managing Director of Manifoldia, Ltd., printers, West Bromwich, and a former treasurer of the Birmingham Chamber of Commerce, died on February 28. Mr. Plant was at one time chairman of the management committee of the heavy industries section of the British Industries Fair, and personally conducted the publicity campaigns. He was also a past President of the Birmingham Rotary Club.

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WILLIAM DIETERICHS

Mr. DEAN CHANDLER writes:

The untimely death of my friend William Dieterichs is lamented not only by his colleagues of the North Thames Gas Board but by many who knew him well outside that inner circle of his friends. A man of outstanding ability and charm has been taken from our midst and we are all poorer for his passing. The high esteem in which our lamented friend was held was clearly evident at the graveside and in the memorial service in St. Matthew's Church where many of his friends from many quarters gather to pay affectionate respect to his memory.

I have known William Dieterichs as a genial friend for many years and as one outside the inner circle of his colleagues I am constrained to add my appreciation to those already published in the *Journal*. My friend was a man of transparent honesty in all his ways and of whom it can be said in all sincerity 'He walked with truth and a friendly heart.' Edward Young's fine words, slightly paraphrased, are entirely appropriate to him.

'His purpose firm was equal to the deed:
He did the best his circumstances allowed,
Did well, acted nobly; angels could no more.'

William Dieterichs was entirely unaffected by success, so often the spoiler of one's better self, and to the last he retained that refreshing simplicity of character that so impressed me when I first came into contact with him. He had a heart of gold the glint of which was often seen in his dealing with his fellows. He was not, however, easily duped; he knew the world well enough not to be imposed upon. He was always accessible to those in need of practical sympathy and help and none was afraid to approach him with their problems. That appraisement of his character will I know be endorsed by all who knew him well. As Chairman of the Industrial Gas Development Committee, happy memories of him will endure. He was always in good humour and our deep respect for him was deeply tinged with genuine affection. He had a happy way of getting the best out of the members of Committee.

Standing by the graveside of our departed friend, another who knew him well whispered in my hearing 'If William had lived and worked less strenuously in recent years he might have continued with us yet.' He was not, however, built that way; for there was always the urge to be up and doing, with insufficient thought for his own well being especially in the war period when he did much to help the country in its munitions drive. As I left the graveside the reflection uppermost in my mind was, 'All men think all men mortal but themselves.'

Of his inborn engineering ability and skill I need say little here. Many examples of his ingenuity are known to us all. The gas industry is the poorer for his passing and with many others I shall feel keenly the loss of a true and lovable friend for many a day to come.

Referring to the question of the correct colouring of gas cylinders, the 73rd annual report of H.M. Inspectors of Explosives for 1948, states that the standardisation of cylinder fittings was within the original terms of reference of the Gas Cylinders Research Committee; but by arrangement the work on the standardisation of cylinder valves, a colour scheme for cylinders and the application of safety discs for carbon dioxide cylinders was undertaken by the British Standards Institution. The colour scheme adopted is set out in British Standard 349. The present Home Office Committee has recommended that cylinders should be coloured in accordance with that specification and not according to the particular purpose for which the cylinder is to be used, *e.g.*, carbon dioxide cylinders should be painted black and not red when used in fire-fighting apparatus. During the year, 61 accidents involving petroleum spirit or petroleum mixtures were reported, causing the death of 17 persons and injuries to 109 persons. Twelve accidents, resulting in 14 deaths and injuries to 44 persons, occurred in the use of petroleum spirit.

The Care of Two Million Meters

London Juniors Visit North Thames Meter Department

THE London Junior Gas Association paid a visit on February 22 to the Meter Department of the North Thames Gas Board at Pound Lane, Willesden, when some 40 members made an afternoon tour of inspection. These works which were opened in 1929, cover an area of over two acres with a floor space of more than 90,000 sq. ft. and are conveniently situated in the centre of the board's area.

The work of the Department which was seen by the visitors is threefold. First, it is their responsibility to purchase and issue domestic meters. These are bought unpainted and are then painted in standard colours before being sent out in bulk to district stores. All prepayment meters and 10% of ordinary meters are tested prior to issue. Secondly, the Department tests and specially paints large industrial and commercial meters, ranging in capacity from 700 cu.ft. to 60,000 cu.ft. per hour, of which there are over 12,000 in use in the board's area. Any query raised concerning meter performance leads to testing *in situ* by members of the Meter Department staff, and a number of wet test meters used for this purpose were seen in the course of the visit in the meter testing section. Last but not least, station meters on the board's manufacturing stations, of which there are 114, comprising 75 wet drum meters, 34 Connersville, and five B.M., are given an annual test.

Statistics

The total number of meters on the board's district is now 1,917,592. Of these over 1,300,000 are of the prepayment type and 12,112 are industrial meters. Last year some 211,000 domestic meters were received from the district, approximately 217,000 were issued to the district, 125,000 new meters were purchased, 85,000 were repaired, and 117,000 were condemned. On the industrial side, 1,355 were received from and 2,079 were issued to the district, and 1,540 new industrial meters were bought.

Divided into four groups, the visitors were invited to 'come and go as you please,' by Mr. R. D. Diamond, General Manager of the Meter Department, and to concentrate on those aspects of the Department's work which most interested them in the short time available. The particular group on which this report is based were first shown the meter store, impressive with its banks of some 40,000 meters of varying makes and capacity.

Test Room

The test room then provided particular interest with its numerous benches, each supplied with water, gas, and air at different pressures, air being normally used for meter testing. Items of interest included a 'museum' of old meters, which contained a cast-iron dry meter of 1864 and a three-diaphragm meter with rotary valve of 1863, two benches of demonstration meters, glass-fronted to show their action, a Holmes Connersville and a Holmes B.M. meter, a gas flow recorder, and a display of different oiling systems in industrial meters. The visitors were also shown in this section a fork lift truck, which is used for raising and moving large meters and the bulk handling of domestic meters. This was later seen in action again in the covered yard unloading a large meter from the specially designed 'Burtonwood' tailboard of a meter delivery van.

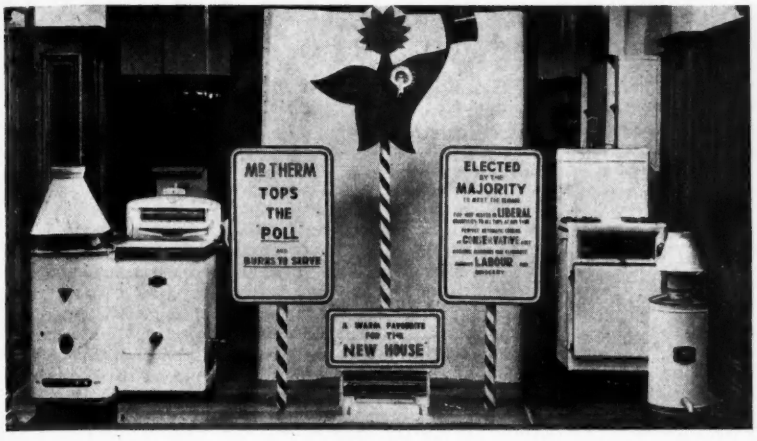
All meters passed by the Department are sent through the paint and oil shop, including new meters from manufacturers. This adjoins the test section, and the visitors were informed that 900 meters a day are painted in the shop's spray booths. Instruments and apparatus for testing the quality of the various paints used were demonstrated, including density, adhesive, and stretching tests. A new instrument, the 'Elcometer,' which indicates the thickness of a coating of paint, proved unusually ingenious. Made by the East Lancashire Chemical Co., Ltd., it relies for its operation upon a powerful electromagnet. When two contacts under the base are applied to the surface under test, the coating of paint acts as a magnetic air gap, the flux across which depends on the thickness of the coating, which is measured by a suitably calibrated flux meter in the instrument.

Finally, the adjusting room was inspected, in which meters requiring minor repairs or adjustments are handled; here, some 400 minor repairs are dealt with weekly, and the meters are then passed on to the paint shop prior to despatch to the stores to await delivery.

After the visit the party was entertained at tea in the canteen. The **President** (Mr. A. H. Savill) said that this was the third occasion on which the London Junior Gas Association had visited Pound Lane, the previous visits having been in 1923 and 1930. Their visit had been the first they had made to the North Thames Gas Board since nationalisation, but whatever change had been brought to the industry, there had been no change in the warmth of the reception they had been accorded. Their thanks were due to Mr. Diamond and the guides who had so ably shown them round the works.

Mr. R. D. Diamond, in reply, said that they had taken some pride in making the arrangements for the visit themselves. He trusted that the visit had been of interest, and he extended to the members an open invitation to come along to Pound Lane at any time they felt that the Department might be of assistance with a particular meter problem on the district.

Left: A new 1,800 cu.ft., high efficiency meter, manufactured by Vanda Meters, Ltd., is inspected in the test room by members of the London and Southern Junior Gas Association, accompanied by Mr. R. D. Diamond, Manager of the Meter Department (fourth from the right). Right: A fork-lift loading truck, used by the Department for lifting large industrial meters, is seen in action in the covered yard at Pound Lane.



Topicality was the key-note of this ingenious and attractive showroom window display, which was designed by Mr. Bergg, Showroom Manager of the Maidstone undertaking, for use at Maidstone during the election period. The names of the three parties were painted in party colours, the remainder of the colour scheme being red, white, and blue.

Industrial Relations

Proposing the main toast of the evening at the annual dinner of the National Union of General and Municipal Workers, at Treforest, the Chairman of the Wales Gas Board, Mr. T. Mervyn Jones, said the Union was 60 years old and it was right and proper that they should look back and see what had been accomplished over the years.

He outlined the growth of the Union from its 15,000 members in 1889 to its present 800,000 members, and paid tribute to the outstanding part it and its leaders had played in the machinery for joint consultation and negotiation which had ensured industrial harmony in the gas industry and fair conditions for those working in it. 'It is truly a model of its kind,' he said. He made special reference to Mr. W. E. Hopkin, first Chairman of the new Wales Area Joint Industrial Council for the Gas Industry.

On the future of the Union, Mr. Jones remarked that it was not right to say that it was now and would always be its function properly to present and always to fight for the full recognition of the rights in reward and conditions of the operative; just as equally it was the function of management, be it a private owner or a public board, no less forcefully to present the other principle. At all times both must be properly presented and due regard had to each. In the process a proper balance and harmony would be achieved between them. The realm of joint consultation in which the Union must play its part to the full was large now and would be ever-increasing in the future.

Professor D. M. Newitt, F.R.S., will deliver his Presidential Address at the 28th annual corporate meeting of the Institution of Chemical Engineers at the May Fair Hotel, Berkeley Street, on April 14. His subject will be 'Technology and the State.' The annual dinner will be held in the evening.

A New Grey Edition, 'A Background to Some Economic Problems in the Gas Industry,' by D. G. Rose (Communication No. 352/161), has been published by the Institution of Gas Engineers. This is available from the Institution, 1, Grosvenor Place, S.W.1, price 2s. 6d., post free.

The Chairman of the Northern Gas Board has approved a recommendation by the committee of Divisional General Managers that the G.L.C. circulator type water heater should be offered on simple hire at 10s. per quarter. The cost of water work will be extra and charged as a single initial payment, and divisional or unit managers will be free to establish a uniform fixing charge.

A Slight Decrease in coal production was recorded in the week ended February 25 when 4,339,800 tons were available for sale, against 4,352,200 in the previous week. Manpower in the week ended February 18 showed a further decline of 200 to 706,000, including a loss of 100 face workers. In the week ended February 24 11,577.5 mill. cu.ft. of gas were available at gasworks, against 12,160.7 mill. cu.ft. in the week before, and electricity supplies also fell over the same period from 1,081.2 mill. to 1,038.2 mill. units.

Scunthorpe Town Council is to ask other local authorities interested in its dispute with the East Midlands Gas Board if they will share the legal costs of defending any proceedings instituted against the Council. Scunthorpe is resisting the board's claim for £20,319, the profit made on the local gas undertaking in the two years before nationalisation, on the grounds that by its own private Act of Parliament the Council was required to turn over any profit from gas and electricity undertakings to the general rate fund. The town claims that this Act has not been repealed, but the board has indicated that High Court action may be taken to recover the money.

Radiation, Ltd.

The Directors of Radiation Ltd., have recommended the payment of a final ordinary dividend for the year 1949 of 7½%, less income tax, which with the interim dividend of 5% paid in October last, makes a total of 12½%, the same as for the previous year. The aggregate profits of the Radiation Group for the year 1949 were: Gross £914,991 and net £431,545, after providing for profits tax and income tax, compared with £844,399 and £382,931 in the year before. The annual general meeting will be held on March 30.

Mrs. Brian Wood, wife of the Secretary of the North Thames Gas Board, launched the board's newest collier, the M.V. 'Accum,' at Grangemouth on February 20. The vessel will carry 2,700 tons of coal at 10½ knots from the north east coast to Nine Elms or Fulham. Mr. Brian Wood is on Mrs. Wood's right in the photograph.

ADMINISTRATION OF THE SCOTTISH GAS AREA

By SIR ANDREW CLOW, K.C.S.I., C.I.E., M.A.,
Chairman, Scottish Gas Board

An address given at a largely attended meeting of the Scottish Junior Gas Association, both Eastern and Western Districts, held at Falkirk on February 25 ; the President of the Western District, Mr. R. F. Bell, in the chair

SIR ANDREW at the outset explained that the Scottish area was by far the largest entrusted to any of the gas boards. Scotland was half the size of England and the Scottish area was greater than the sum of the four biggest areas held by English gas boards. While a considerable part of this area had only a small population and little or no gas, undertakings were scattered widely over the country. There were three north of John o'Groats and the distance between the most outlying gasworks in Scotland was almost as great as it was in England as a whole and more difficult to cover. Although a big area presented special difficulties, the main factors which rendered administration elaborate was not this but the number of undertakings. In Scotland the board had taken over 193 undertakings, a much larger number than that in any other area. Of these about a third had been held by town councils (with one for which a county council had been responsible) and about two-thirds by companies, including a few owned by individuals. There were still three undertakings not taken over. These belonged to the National Coal Board and were in Midlothian. The undertakings owned by town councils included those of all the big cities and, in consequence, produced the great bulk of the gas, but administrative problems were not proportionate to gas production and the many scattered undertakings conducted by companies involved a heavy share of administrative duties.

The Scottish board, continued Sir Andrew, was the strongest of the 12 boards; he was referring not to its quality, of which

Left to Right: W. Ewing (Engineer and Manager, Falkirk gas undertaking), R. F. Bell (President, Western District, Scottish Junior Gas Association), S. K. Patterson (President, Eastern District, Scottish Junior Gas Association), Sir Andrew Clow (Chairman, Scottish Gas Board), and D. J. Colvin (Divisional Controller, Edinburgh and South-Eastern Division, Scottish Gas Board).

he would venture to say nothing except that it consisted entirely of Scots, but to the character of its composition. No other board had as many as four full-time members, the majority of English boards having only two. There were eight members in all and four of them had been experienced managers of gas undertakings, bringing knowledge of both small and large undertakings. He doubted if any other board could claim to have so much experience of gas management. That gave a wealth of the experience of the board in various matters, of which administration was one. But despite that, the board was not anxious to become an administrative body. It was primarily concerned with policy, while administration, in the main, was the task of others. Important responsibilities fell on the divisional controllers and group managers, but this did not curtail the responsibilities of managers and their assistants. Indeed all the divisional controllers and group managers had, in addition to their supervisory functions, direct charge of management of leading undertakings. This had an obvious disadvantage, and if both personnel and money had been abundant he would have preferred to see the various regions under the care of officers who did not have their own centres to manage. There might later be some developments in that direction, and it had been adopted by other boards. But the present system, though not ideal, had some

Another snap taken by the JOURNAL *during the Falkirk meeting.*

clear advantages. One was that those giving a lead in administration were themselves sharing the difficulties of management and could realise how important it was to leave to managers and their assistants a big share in responsibility while being ready to give assistance, especially to those in smaller places.

Character of Administration

A variety of responsibilities fell on those he was addressing, with their colleagues and local managers. One was that of maintaining and improving the technical aspects of the service. There was perhaps a temptation for engineers to lay too much stress on that. Highly qualified men were tempted to stress the importance of those subjects of which they knew most and to underestimate the weight of those with which they were less familiar. Engineering grasp and equipment constituted a valuable asset, but service in the industry was not a professorship of gas technique. It made wider calls than that. Like most other things in life it was a test of personality, and one had to remember that one was serving a big public. That public was not a statistician's collection of 'economic men,' but widely varying men and women whose needs and desires required study. A few of these would be working with them. They met most of them casually or not at all. But their success would depend on how they understood them, appreciated their varying circumstances, sympathised with them, and realised what their work meant to them.

In a wide area with so many undertakings it was not surprising that administration was by no means uniform. It differed substantially from place to place because conditions and temperaments varied. He did not want to see it uniform and they were not looking for any kind of regimentation. They had not attempted to make the price uniform even in

districts close to each other. Price would continue to depend on various circumstances. But they gained by sharing experience. It was good to go round and see how colleagues were faring and there were administrative points which one district could learn from another.

One important change affecting nearly all undertakings should be borne in mind. Until the Gas Act came into force nearly all undertakings had a local body to supervise and direct its course. It might be a town council or local directors, with local knowledge and various views and experiences. The manager, therefore, had guidance, sometimes perhaps embarrassing, but often advantageous, of a local organisation, to which he was responsible. They were free from such an embarrassment now but lacked that assistance. Policy rested with a more distant authority, advice was not so accessible, and there was a greater degree of independence. That might have some advantages, but it was important to retain contact with local authorities, to give weight to the views they might express. They should try to be accessible to all who had help and advice to offer. The gas board had the advantage of a consultative council, most of whom were experienced public men from town councils. Local committees would give closer touch with different regions; but there were many other public-spirited men with whom contact would be helpful and wise because they could bring home the view of the public whom they were all trying to serve.

Co-ordination

One advantage of the co-ordination of the various undertakings was the linking of those which could be conveniently joined. Unless there was a big change in technical possibilities, the supply of gas in most of the Scottish areas was unlikely to be incorporated in a grid or anything of that sort. But there were some places where a degree of co-ordination should be possible. They had already started to join up some places. Before nationalisation there had been a discussion between Falkirk and Grangemouth town councils for example, regarding a linked service, and there were other places like Denny, Polmont, and even Boness with possibilities of connection. Apart from the linking of gas supply, small groups of undertakings could be linked for administrative purposes. This would ensure a wider personnel sharing the duties of several places. Hitherto the manager of a small undertaking had often to perform many varied functions and, however well equipped he might be, it was impossible to discharge them all well. Centres with groups of officers, each with specialised knowledge, had had a great advantage.

Education and Qualifications

Education was an important factor for administrative equipment. Education should always be growing with experience, but there were special opportunities in one's younger days for getting the best qualifications, things which counted later both in making one efficient and in making one competent to hold various appointments. One of the present difficulties, due to the war, was frequently the scarcity of candidates with sufficient qualifications. There were men without adequate training who, through grit and hard work and character, had risen, but it was a handicap not to be properly trained. The future conduct of the industry lay with those who had done their best to enrich their knowledge in their younger days. Their own Association and similar associations, with visits to gasworks, added to their education, but the value of these things depended largely on the basis of education they had provided for themselves.

Appointments

Dealing with the making of appointments, Sir Andrew said he would like those in the industry in Scotland to think of themselves as a service with the fellowship and *esprit de corps* which most services carried. When vacancies occurred the choice was not limited to those serving in Scotland. Recently they had secured one responsible officer from England and more than one of their own officers had gone to responsible posts in England. But experience in Scotland was valuable and, normally, posts would go to those possessing that experience. It was worth remembering, in that connection, that movement helped to develop experience. The man who had served in three or four different places had gained a clear advantage over the man who had been limited to one. The man who knew both large and small undertakings had widened his experience, and it was a help to have served in posts of varying responsibility. Similarly, service under different officers was a help. One could thus absorb different outlooks and more numerous ideas. They should not be too critical of those under whom they had to serve. When they were young they were tempted to regard any senior's differences as weaknesses, but men of different types had all something to teach.

Promotion

When he was young he imagined that men responsible for filling posts had an embarrassing choice between equally excellent candidates. He could assure them it was nearly always the other way about. There were seldom, if ever, a perfect candidate, and the choice generally fell on one who was not ideal but was the best of the bunch. It was a consolation to know that one's imperfections might not prove fatal. It also made it important to study, not the weaknesses of others, but their assets and sources of strength. In the Civil Service and elsewhere the tendency was to concentrate on faults. Some authorities drew attention to mistakes but failed to commend what was done right. Errors could be serious and required correction but it was just as important to encourage and appreciate what was done correctly and well.

Sir Andrew concluded by saying how much he had been impressed by those maintaining and developing gas in Scotland. He hoped their interest and happiness would grow.

DISCUSSION

Mr. **A. McInnes** (Dumbarton) said the size of the audience was a compliment to the speaker, as the Juniors did not now get their expenses when attending such meetings. He asked whether the board had under consideration the assistance of men in technical education, where the course was long and the incentives were not so good. There was no getting away from the fact that money always counted. He agreed that experience in both small and large works was admirable, but they could not expect a man to move from a large to a small place without having regard to salary considerations.

Mr. **G. Wood** (Dunfermline) agreed that one should not criticise one's senior in front of other juniors but considered that one was entitled to criticise if one did not agree with a decision.

Mr. **T. B. Livingstone** (Perth) suggested that the board should do something about the methods of teaching in Scottish colleges. He had been a lecturer for two years and there had been difficulty in getting sufficient numbers to form a class. The needs of students were widely divergent. In England they had some rough pattern of the value of posts advertised, but there seemed to be no pattern as far as Scotland was concerned. It would help if the Scottish board would hurry on with training scheme and could provide houses to accompany certain posts.

Mr. **Robert Cowie** (Hawick) suggested that the intake of young men into the industry was slowing down. For many years the industry had been regarded as a dying concern, but the board would reap a rich harvest if it paid attention to the juniors. The board had gone about its task in a 'canny' way, making no sweeping changes and this had given them confidence. They had been impressed and encouraged by Sir Andrew's outlook.

Sir **Andrew Clow**, replying, said he wanted to encourage attendances at Association meetings and favoured doing what was legitimate regarding expenses. In regard to experience at different works, a man could not be expected to move from one place to another without regard to finance. Keen and intelligent young men were not abundant, and they wanted a boy with a promising school career to feel that the industry offered prosperity, happiness, and usefulness. With 193 undertakings in their care there was a danger that they might 'pattern' too quickly.

Mr. **S. K. Patterson** (Galashiels, President of the Eastern District) proposed a comprehensive vote of thanks.

GRAPHICAL PRESENTATION OF THERMOSTATIC EQUILIBRIUM

By D. M. HOLLOWAY, B.Sc., M.Inst.Gas E.
Senior Lecturer in Gas Engineering, Westminster Technical College.

THE method of analysis of thermostat performance to be described has been found to be of considerable value in conveying to students a clear picture of the nature of the equilibrium obtained, and of the degree of precision to be expected, with the usual type of direct acting gas thermostat. The method is quite straightforward, but as far as the author is aware no published description of it has appeared in the technical literature of the subject.

In any application of a direct acting thermostat both the appliance and the thermostat may be regarded separately as units possessing, when in thermal equilibrium, a characteristic gas-rate/temperature relationship for any given set of external conditions. (Gas quality, gas pressure, ambient temperature, thermostat dial setting, &c.) Curves may therefore be plotted showing this relationship for each of the two units. The shape of these curves and the factors influencing the shape in either case will now be considered.

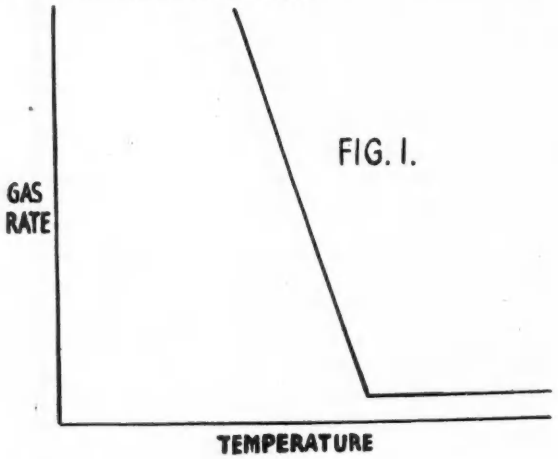


FIG. 1.

Thermostat Characteristic

For this unit the temperature to be taken is evidently that of the control element, and for simplicity a single temperature will be assumed equivalent in effect to the combined influence of the slightly varying temperatures at different parts of the control element usually obtained in practice. If one considers the effect on the gas rate passed by the thermostat at a constant pressure differential, of variations in this temperature, it is seen that a curve of the shape shown in Fig. 1 will be obtained.

The left-hand portion of this curve will be linear, as shown, if:

(1) Equal temperature changes produce equal movement of the valve.
(2) Equal movements of the valve produce equal changes in gas rate.

These two assumptions are only approximately true, the former being affected by the known variations in the coefficients of expansion of the materials used for the control element, of which the case of the usual invar-brass combination will be considered later; and the latter by the pressure loss in the gas-ways of the thermostat and the variation in the discharge co-efficient of the valve opening.*

* The error in assuming that with the normal type of poppet valve the minimum area is proportional to lift is negligible with the small lift typical of gas thermostats.

The effect of these approximations is, however, swamped by the much larger effect due to the fact that, in practice, a constant pressure differential across the thermostat is not

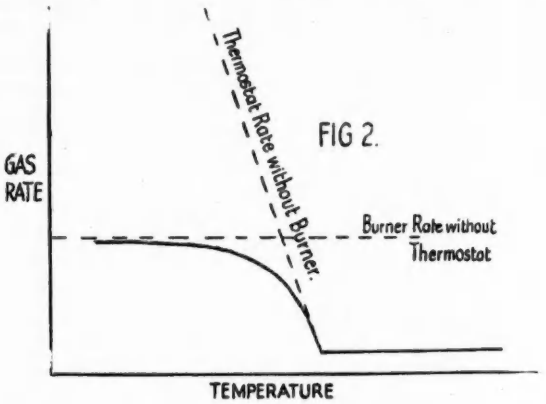


FIG 2.

obtained even with an unvarying inlet pressure, since part of this pressure is required for operating the burner.

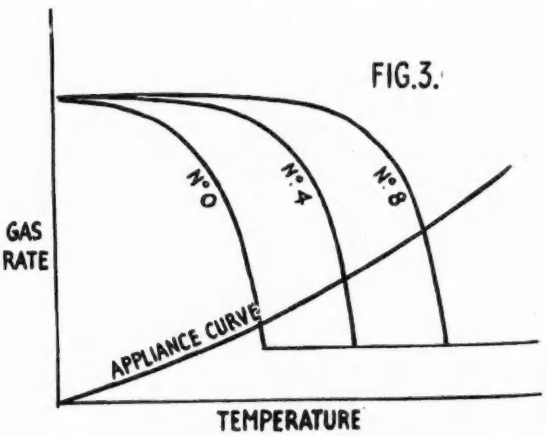
The effect of the introduction of the burner on the resulting gas rate can be calculated by the usual formula for two orifices O_1 and O_2 in series:

$$R = \sqrt{\frac{R_1^2 R_2^2}{R_1^2 + R_2^2}}$$

Where R_1 = gas rate through orifice O_1 if O_2 is not present
R_2 = " " " " O_2 " O_1 " " "
and R = " " " the two orifices in series

The straight line of Fig. 1 is modified in this way to give the curve shown in Fig. 2.

Where the thermostat is adjustable, movement of the control



knob corresponds to a lateral displacement of the whole curve, so that a family of curves, relating to the various settings, is obtained (see Fig. 3).

Appliance Characteristic

The temperature to be taken in this case should again be that of the location of the thermostat control element in order

that the true equilibrium temperature may be deduced. In practice it is more likely that the gas rate needed to maintain thermal equilibrium will be known in relation to the temperature at some other point, or even the average of a number of different temperatures at various points. This is a real difficulty but may not in all cases be a serious one. For example, in a cooker oven the maintenance rate is perhaps known in relation to the centre oven temperature measured by B.S.I. globe thermometer, while the thermostat 'rod' is located at the top of the oven. The error in assuming that the two temperatures are the same is minimised in this case because the two factors affecting the temperature, convection and radiation, produce differences in opposition as one moves from centre oven to a position near the roof, so that the final rod temperature may not be very different from the B.S.I. centre oven temperature. In other cases, where an appreciable difference is known to exist, this must be allowed for.

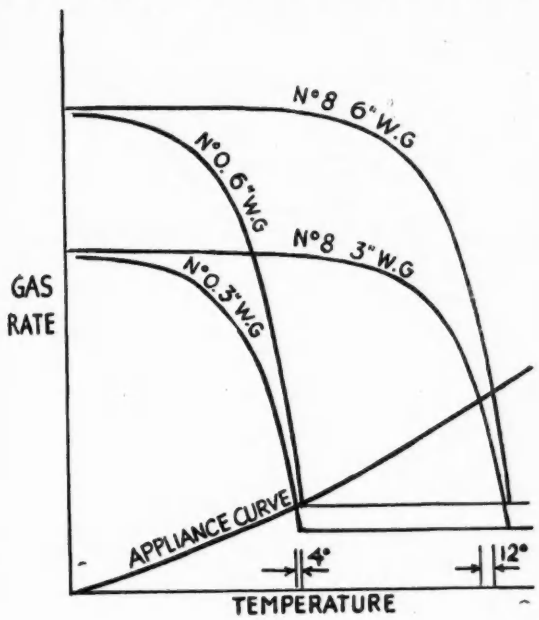


FIG 4a

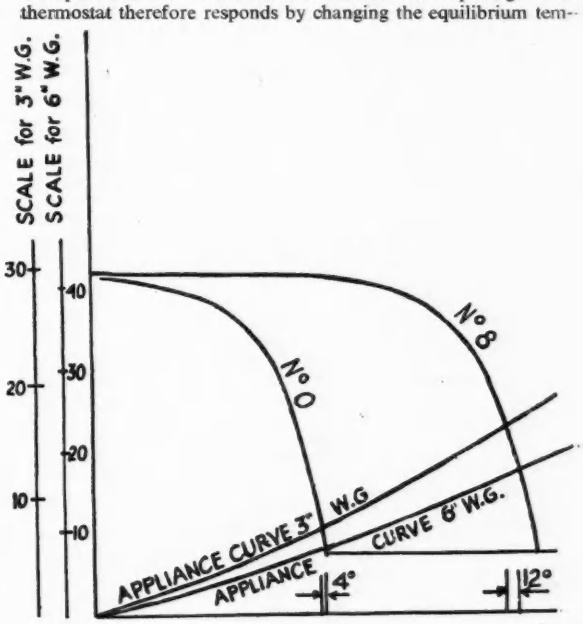


FIG. 4b.

The appliance characteristic will usually be a line starting from the temperature axis at room temperature and concave upwards to a degree depending on the type of appliance and its range of temperature operation.

Equilibrium

If the appliance curve and the family of thermostat curves are superimposed, the combined graph shown in Fig. 3 is obtained, and it is evident that the equilibrium temperature for any particular setting is given by the point of intersection of the thermostat characteristic for that setting and the appliance characteristic. Using this combined graph it is easy to see the effect produced by different factors on the behaviour of the thermostat.

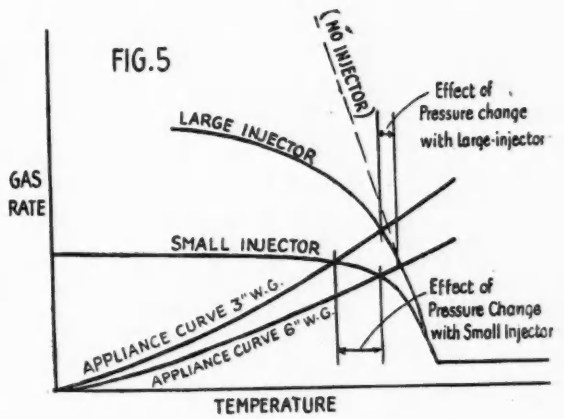
Note 1.—The vertical scale has been doubled c.f. Figs. 1 and 2.

Note 2.—The dial numbers given are not intended to indicate any particular make of thermostat.

Pressure

An increase in inlet pressure will not affect the validity of the appliance characteristic, but will magnify in a fixed ratio all the gas rates relating to the thermostat curves. In other words, the vertical height of all the thermostat curves is increased by a given percentage. When dealing with a family of thermostat curves it is simpler, and will not affect the equilibrium temperature obtained, to alter the rate scale so that the height of the thermostat curves is unchanged, and to lower the single appliance curve to suit the new scale. Both methods are shown in Fig. 4a and b, only two thermostat curves being included for the sake of clarity.

The equivalence of these two diagrams shows clearly that, as far as the thermostat is concerned, raising the inlet pressure to an appliance by an amount which *increases* the gas rate *obtained* with a given valve opening in a fixed ratio, say, 2:3, has the same effect as the application of lagging to the appliance which *reduces* the gas rate *required* in the ratio 3:2. In both cases the appliance will overheat, and what is required of the thermostat is a smaller valve opening. The thermostat therefore responds by changing the equilibrium temperature to the slightly higher value required to produce that reduction in opening.

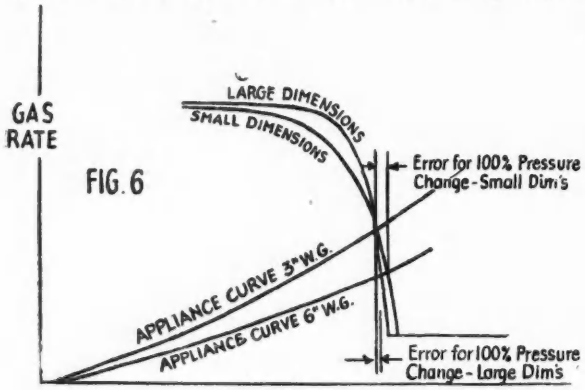


It will be seen that the change in equilibrium temperature caused by a given change in inlet pressure is dependent on the slope of the portion of the thermostat curve adjacent to the point of intersection, which depends in turn on the rate of

opening of the valve with change in temperature. It is also dependent, at high settings, on the size of the burner orifice (see Fig. 5).

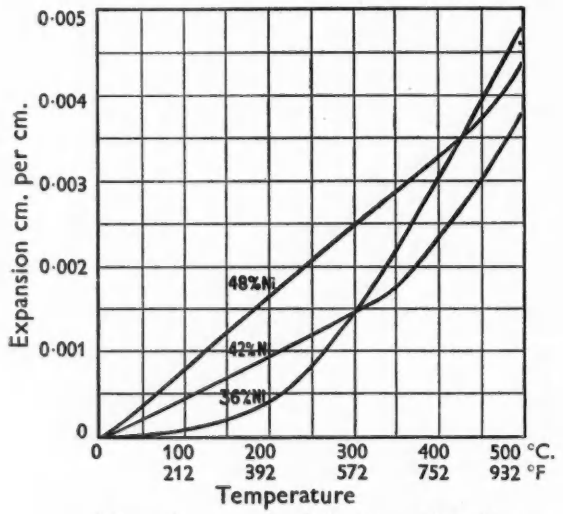
Thermostat Dimensions

The two principal dimensions of a thermostat are the rod length and the valve periphery. Increase in either of these will produce a proportional increase in the valve opening that results from a given temperature fall; or, putting it another way, the same valve opening will be produced by a smaller temperature fall. This effect can, therefore, be shown as a change in the horizontal distance occupied by any particular portion of the thermostat curve. This is shown in Fig. 6, the


GAS RATE
LARGE DIMENSIONS
SMALL DIMENSIONS
Error for 100% Pressure Change - Small Dim's
APPLIANCE CURVE 3" W.G.
APPLIANCE CURVE 6" W.G.
Error for 100% Pressure Change - Large Dim's
FIG. 6

two curves being drawn to represent the case where the two thermostats are adjusted to give the same equilibrium temperature at normal inlet pressure (3 in. w.g.).

The effect of increased dimensions is to render the slope of the thermostat curve more steep and therefore to reduce the effect of pressure variations. This can readily be proved from first principles.



Thermal expansion of the iron-nickel alloys of the Nilo series in the fully annealed condition.

Fig. 7.

Expansion Characteristics of Control Unit

The discussion will be confined to the simplest case of two rigid elements of different thermal expansions as exemplified by the familiar brass tube and nickel-iron (invar) rod.

In order to analyse this aspect of thermostat performance, a slight re-arrangement of the method of presentation is desirable, the vertical scale of the graph being altered from the *gas rate* corresponding to a given temperature to the equivalent *valve opening* for that rate. The appliance curve ceases, of course, to be independent of the thermostat with this change so that for general purposes the original method is preferable.

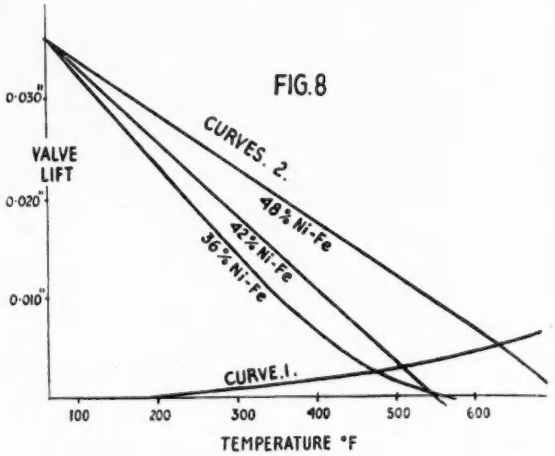


FIG. 8

It will be seen that the two curves obtained in this case represent:—

(1) The valve opening required in the thermostat to give various equilibrium temperatures in the appliance.

(2) The valve opening resulting from the combined effect of the "cold" valve opening and the differential expansion obtained at various temperatures.

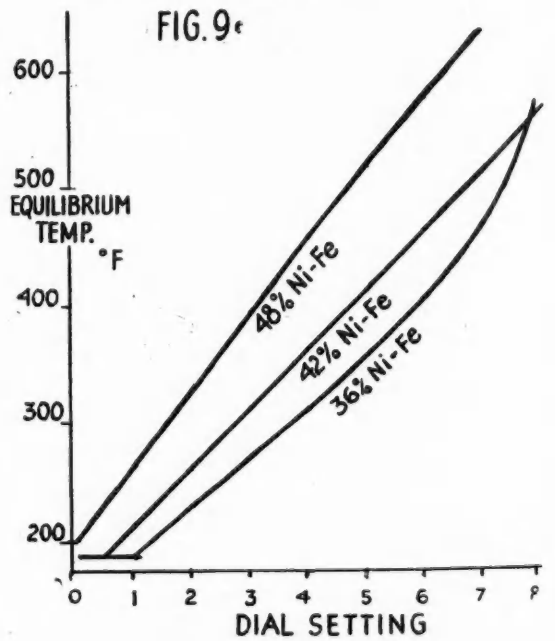


FIG. 9

Curve 1 now includes all the factors so far discussed, while Curve 2 may be obtained directly from the thermal expansion data of the two materials employed in the control element.

For the sake of illustration, it will be assumed that, for the appliance, temperature rise is proportional to thermal input, a condition approximately met by cooking ovens. In this case the shape of Curve 1 can be deduced on the lines already indicated (see Fig. 8).

(*Continued on p. 598*)

HEAT AND WATER VAPOUR IN CRUDE GAS*

By F. E. CRADDOCK

(North Thames Gas Board)

IT is unlikely that anyone closely concerned with the manufacture of gas would be unaware of the water vapour associated with it, yet it is probable that its utility is not fully appreciated. The water carried by gas, although invariably considered an embarrassment until finally reduced to such small proportions that it no longer appears on the 'district,' does in fact play an important part in a number of the processes familiar to the gas engineer. In some of these the effect is obvious, as in the reduction of sensible heat in the retort house, while in others its influence is less apparent.

The main purpose of this paper is to record some of the results of a study of the heat content of crude gas—*i.e.*, the heat carried by the gas as distinct from useful heat indicated by its calorific value—but it seemed worthwhile to extend the scope to the examination of gasworks processes in general, and to discuss briefly the extent to which water vapour influences either the design or the performance of certain units of plant. For example, in recent years much attention has been directed to the design of condensers and empirical methods have given way to more precise treatment based on modern ideas of heat

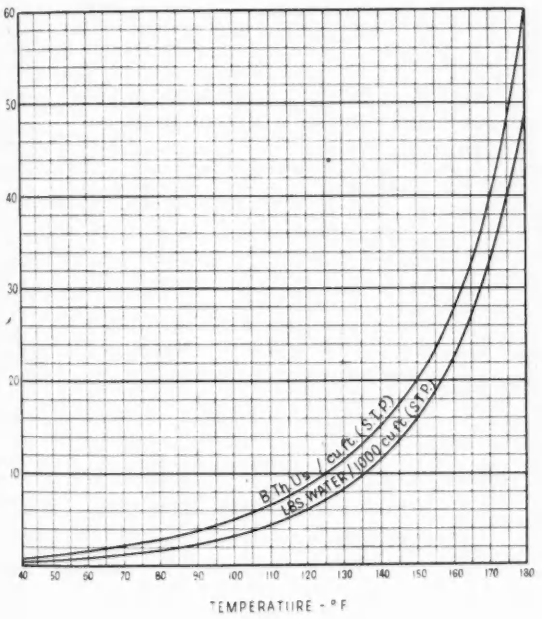


Fig. 1.

transfer and their practical application. Economy in design depends upon an exact knowledge of the conditions present in any given circumstances and of these the heat to be dissipated is of major importance. This quantity may be accurately assessed if the saturation temperature of the hot gas is known, a value more often assumed than measured. To regard the gas as saturated at the indicated temperature, as is often done, may lead to serious discrepancy which becomes more marked at high temperatures. However, the dearth of experimental data is perhaps not surprising when one considers the nature of the problem involved in the determination of water vapour in hot crude gas laden with tar and naphthalene vapour, carbon particles, and gases very soluble in water such as ammonia, or to a less extent like hydrogen sulphide and carbon dioxide.

Some of the methods employed lack precision or are cumbersome to use and progress towards a more complete knowledge of the heat capacity of crude gas has necessarily been slow in the absence of reliable experimental evidence. The need for strictly accurate work may perhaps be better understood by reference to Fig. 1 which illustrates this point more clearly. Thus an error of 1°F. in the measurement of the gas temperature at 60°F. will introduce a discrepancy of 50 to 60 B.Th.U. per 1,000 cu.ft. of gas whereas at 160°F. a similar error represents a difference of 900 to 1,000 B.Th.U. per 1,000 cu.ft.

Before any further advance could be made this difficulty had to be overcome and when suitable apparatus had been devised and tested much interesting data was collected which supports ideas already put forward by other workers, based previously on physical considerations alone.

It is proposed first to indicate how water vapour gets into the gas, the factors responsible for the variable quantities obtained, the results of actual determinations and finally its ultimate fate.

2. Sources of Water Vapour

Water vapour finds its way into the gas from several sources, arising mainly in the retort house or water gas plant, and derives in part from the coal itself.

(a) Moisture in Coal

The whole of this moisture is transferred to the gas soon after coal is charged into retorts, being converted into steam as heat penetrates the mass. It is, therefore, a simple matter to calculate the amount contributed from this source and the quantity will naturally vary with the composition of the charge, whether Durham or Yorkshire coals, nuts or run-of-mine, and whether mixed with stock coal. It should be borne in mind that evaporation of this water involves an expenditure of energy, represented as sensible heat and as heat of vapourisation, which is not usefully recovered and has subsequently to be removed in the condensing system.

(b) Oxygen in Coal

The removal of moisture is followed, as primary decomposition proceeds, by the generation of simple inorganic compounds of carbon, hydrogen and oxygen. The proportion of water vapour produced is dependent on the amount of oxygen originally present in the coal, which reacts under the influence of heat to form carbon monoxide, carbon dioxide and water, the relative quantities of each gas being determined by the class of coal, operating conditions, &c.

If the oxygen content of the coal is known the amount of water produced from this source may be calculated from the gas analysis provided no steam has been introduced in the retorts. For example, assume coal containing 5% oxygen is carbonised in horizontal retorts producing per ton of coal 12,000 cu.ft. (S.T.P.) of gas containing 2% CO_2 and 8.0% CO.

The chemical equations are

$$C + O_2 = CO_2$$
$$2C + O_2 = 2CO$$
$$2H_2 + O_2 = 2H_2O$$

Oxygen content of coal = 5.0% = 112 lb./ton

The molecular weight of oxygen (32 lb.) occupies 386 cu.ft. at S.T.P.

Therefore volume of oxygen obtained from coal

$$= \frac{112}{32} \times 386 = 1{,}350 \text{ cu.ft./ton}$$

Volume of oxygen required for formation of CO_2

$$= \frac{2}{100} \times 12{,}000 = 240 \text{ cu.ft./ton}$$

Volume of oxygen required for formation of CO

$$= \frac{1}{2}\left(\frac{8}{100} \times 12{,}000\right) = 480 \text{ cu.ft./ton.}$$

* Paper presented to the London and Southern Junior Gas Association February 10, 1950.

Volume of oxygen available for formation of water
$= 1,350 - (240 + 480) = 630$ cu.ft./ton.

Therefore water vapour formed $= 630 \times 2 = 1,260$ cu.ft./ton
Since 18 lbs. of water occupy 386 cu.ft. at S.T.P. the weight of water formed $= \frac{1,260}{386} \times 18 = 32.6$ lb./ton
$= 2.7$ lb./1,000 cu.ft. (S.T.P.)

(c) **Steaming**

The design of vertical retorts enables steam to be introduced with the object (a) of controlling C.V. and (b) of recovering part of the sensible heat from the coke, thus increasing the thermal yield by production of water gas and by its stripping action as it passes up through the charge. Since one cannot hope to obtain anything like 100% efficiency of steam decomposition the water vapour content of the gas will vary with the proportion of steam undecomposed, which itself depends on the rate and period of steaming, whether the retorts are continuous or intermittent, and the temperature of the coke. The last is most important, and where air-cooling of the coke chamber is provided steaming efficiencies are considerably reduced.

(d) **Liquor Sprays in Offtakes and Hydraulic Main**

Crude gas leaves the mouthpieces of horizontal retorts at temperatures ranging from say 500°C. during the period of maximum gas production to perhaps 370°C. or lower in the case of top retorts at the end of the carbonising period. In intermittent vertical retorts the gas temperature probably reaches 600°C. while in coke ovens 700°C.-800°C. may be expected. In continuous vertical retorts where the gas is cooled by the incoming coal the temperature may be as low as 250°C. The greater part of this sensible heat must be dissipated before reaching the exhausters, to reduce the load on them and for the better performance of the purification processes which follow. A convenient method of lowering the temperature rapidly is by means of weak liquor sprays, situated as close to the retorts as possible in order to minimise deposits of pitch, and usually resulting in the saturation of the gas. In some cases the gas loses sensible heat so rapidly that the 'virgin liquor'—*i.e.*, the liquor resulting from (a) and (b)—may be more than sufficient to saturate the gas in the hydraulic main so that the excess condenses, and, in fact, the hydraulic main was originally provided as a receptacle for the 'virgin liquor' and a collecting tank was necessary to receive the overflow. Under modern conditions, with higher carbonising temperatures, the quantity of 'virgin liquor' may fall short of the amount required by the hotter gas, and thus evaporation of the sprayed liquor takes place. In these circumstances the provision of make-up liquor to the circulating tank is essential.

(e) **Water Gas**

The water content and consequently the heat content of water gas is comparable with that from horizontals fitted with scrubber standpipes and with gas from intermittents and coke ovens. The efficiency of steam decomposition obviously affects the initial quantity of water carried away from the generator, but the bulk of the water is evaporated when the gas, at a probable temperature of 600°C., comes into contact with sprays in the main leading to the washbox and in the washbox itself, being cooled to about 180°F. but still with its total heat content almost unchanged.

3. Influence of Retort Design

In the foregoing remarks reference has been made to variations in the water content of gas from different types of retort and this aspect will now be considered in more detail.

(a) **Horizontal Retorts**

In general, these variations depend on the opportunities for the gas to lose sensible heat by radiation and convection to the pipe walls, and this occurs to the greatest extent in horizontal settings, especially those arranged in tall beds and with offtakes at each end. The hot surfaces thus provided, by dissipating considerable quantities of sensible heat, reduce the cooling necessary from the hydraulic main onwards, but scarcely compensate for the disadvantage arising from the formation of pitchy deposits and the need for augering to keep the gasways clear, quite apart from the discomfort caused by the resulting higher air temperatures. The development of scrubber standpipes or Congdon pipes, by connecting the retort mouthpieces directly to a standpipe fed with liquor, provides a means of eliminating these troubles to some extent. The sensitivity of gas to adiabatic cooling by water enables the temperature to be reduced rapidly, but while this conversion of sensible heat does rapidly lower the temperature of the gas, by so doing it also reduces very considerably the rate of loss of heat to the surroundings and its total heat content remains practically unaltered and it carries in addition considerably more water vapour. It is, therefore, important to remember that one effect of scrubber stand-pipes is to treble the heat load on the condensers, since much of the heat previously lost by radiation and convection is now retained as latent heat.

(b) **Vertical Retorts**

One of the results of vertical retort design is the elimination of much of the sensible heat loss by keeping the gas offtakes short and by the provision of sprays in them. The water content of the crude gas is, therefore, higher than from horizontal retorts, partly for this reason, but the increase will be less marked in the case of continuous retorts owing to transfer of heat to the incoming coal. In the Glover-West system, where the offtakes are rather longer, slightly lower temperatures prevail at the liquor sprays with a corresponding reduction in the water content of the gas.

The practice of steaming in vertical retorts introduces a further source of water vapour equal to the amount of steam which passes undecomposed through the charge. This means, in effect, that less water will be evaporated at the sprays since the water content is already high but the gas leaves at a higher saturation temperature than is found in unsteamed retorts.

(c) **Coke Ovens**

A feature of coke oven offtakes not found in other retort systems is the steam injector which is used immediately after charging to assist in the removal of the rich gas, and which contributes to the water vapour content of the gas. Sprays are provided in the offtakes and the entire hydraulic system is exposed to the atmosphere with the result that the gas entering the collecting main is almost saturated.

TABLE I.

Properties of Saturated Gas

Temperature °F.	Sensible heat above 32° F. B.Th.U. per cu.ft. at S.T.P.	Total heat above 32° F. B.Th.U. per cu.ft. at S.T.P.	Water content lb. per 1,000 cu.ft. at S.T.P.
50	0.36	1.0	0.57
60	0.57	1.5	0.83
70	0.77	2.1	1.19
80	0.98	2.8	1.69
90	1.19	3.7	2.33
100	1.40	4.9	3.22
110	1.62	6.5	4.44
120	1.84	8.6	6.08
130	2.07	11.3	8.29
140	2.32	15.0	11.41
150	2.58	20.1	15.82
160	2.86	27.8	22.22
170	3.18	39.5	32.14
180	3.56	58.9	48.68

4. Determination of Water in Crude Gas

The heat content of crude gas is made up of the latent heat of its water, tar, and organic vapour content, and the sensible heat of the gas and uncondensed vapours. In this discussion the heat content of tar, naphthalene, and other organic vapours may be neglected as it represents a relatively small proportion of the whole and consideration confined to the heat of condensation of water and the sensible heat of gas and uncondensed water. These quantities may be calculated at any temperature for gas saturated with water vapour at that temperature and values for the sensible heat and total heat content

of gas above 32° F., and its water content are given in Table I and Fig. I taken from 'Gas Cooling with Aqueous Condensation,' by L. Silver[1]. The magnitude and importance of the heat contributed by water vapour is evident from the figures which also show how rapidly it rises as the water content increases with temperature.

The determination of the water content of gas thus suggests itself as a convenient method of estimating the total heat content, and a number of such methods have been used or proposed. It is not, however, as simple a matter as may at first appear, the need for precise measurement having already been indicated, and several refinements are necessary in methods previously adopted. The gas to be sampled has a dewpoint well above atmospheric temperature so that it is essential to ensure that no condensation occurs up to the point where the water is intended to be trapped. For this purpose, the sampling tube may be heated electrically, by far the easiest method both in construction and control. The estimation of water vapour accompanying the gas is not easily accomplished in the presence of tar and other condensible constituents, as well as solid particles, and the usual method in which water is absorbed by a solid or liquid reagent and weighed may not be used since condensation of tar, &c., will vitiate the results. The condensation of the vapours and collection of liquid water offered the best chance of success, provided the water could be suitably separated from the tar and naphthalene, with which it becomes contaminated. The condensation stage may be carried out in vessels immersed in a freezing mixture, preferably crushed solid carbon dioxide mixed with acetone and contained in Pyrex Dewar flasks. At the temperature of −78° C. obtained in this way the vapour pressure of water is so small that its removal may be considered complete. Tar, naphthalene, and light oils are, of course, brought down at the same time, while other constituents such as ammonia, hydrogen sulphide, and carbon dioxide dissolve in the water condensed. Water may be separated from the resulting mixture by distillation in a modified form of the Dean and Stark apparatus, commonly used for the determination of water in tar, and may be measured either gravimetrically or volumetrically. Actually the aqueous distillate is a solution of ammonium carbonate and sulphide, the concentration of which must be determined to enable the quantity of water present to be calculated. Despite the number of manipulations involved, it has been found possible to obtain a high order of accuracy, as indicated by determinations with known quantities of water. A detailed description of the method and apparatus is given in the appendix.

5. Experimental Results

(a) Retort House and C.W.G. Plant

By applying this method to a variety of carbonising systems an interesting and useful comparison has been obtained. It will be appreciated that it is impossible to provide strictly comparable conditions in every case, while the choice of suitable sampling points is dictated by considerations of layout and accessibility of pipework.

The retort house tests, most of which were made on the hydraulic or collecting main immediately after the sprays and before any appreciable fall in temperature occurs, are summarised in Table II.

It will be seen that normal horizontals have the lowest saturation temperature or dewpoint, usually about 140° F. and with a heat content of about 15 B.Th.U. per cu.ft. at S.T.P., while gas from verticals is some 20° F. higher, its heat content ranging from 20 to 30 B.Th.U. per cu.ft. Gas from horizontals with scrubber standpipes, coke ovens, and carburetted water gas plants is usually saturated at temperatures between 170° F. and 180° F., with a heat content of 40 to 60 B.Th.U. per cu.ft. Gas from normal horizontals will generally be saturated by the time it leaves the hydraulic main, but this is far from true in the other cases mentioned, although closely approached in coke ovens where the offtakes are exposed to atmospheric cooling.

TABLE II.

Heat and Water Content of Gas at Foul Main and Outlet of Washbox.

	Gas temperature °F.	Water content lb./1,000 cu.ft. at S.T.P.	Saturation temperature °F.	Heat content above 32° F. B.Th.U./ cu.ft. at S.T.P.
Horizontal retorts	141	11.5	140	15.0
Horizontal retorts	134.5	8.5	131	11.6
Horizontal retorts (with scrubber standpipes) ...	194	31.5	169	38.5
Horizontal retorts (with scrubber standpipes) ...	209	49.6	181	61.9
Horizontal retorts (with scrubber standpipes) ...	188	38.6	174	46.5
Woodall - Duckham continuous vertical retorts ...	164.5	16.9	152	21.8
Woodall - Duckham continuous vertical retorts ...	161.5	14.1	146	18.2
Woodall - Duckham continuous vertical retorts ...	174.7	18.8	155	24.0
Woodall - Duckham continuous vertical retorts ...	168.9	24.6	163	31.9
Glover-West continuous vertical retorts*	204	9.7	135	14.4
Glover-West continuous vertical retorts*	196	12.2	142	17.0
Coke ovens	176	37.7	173	44.6
C.W.G. plant	178	32.3	170	39.7
C.W.G. plant	177.5	32.6	170	39.7

* Before liquor sprays in foul main. Tar sprays used in collecting main.

(b) Condensers

An investigation of the heat and water content of gas yields the most illuminating and perhaps the most profitable results when applied to the working of the condensers.

The primary duty of the condensers is to remove the heat from the gas, and on the proper functioning of these units depends the efficiency of the processes which follow. Nevertheless, condensers are too frequently neglected and tar, ammonia, and naphthalene removal suffer in consequence, leading to further difficulties in working the purifiers. A little more attention given to these units would be amply repaid in trouble-free working of subsequent plant.

The serpentine atmospheric condenser still commonly employed has certain advantages over the water-tube type which has largely replaced it. It does, however, cover a large area and the water-tube condenser will be increasingly employed in new constructions and in the modernisation of existing works, although in certain circumstances such as those described by Woodcock[2], the installation of an atmospheric condenser may be the best way of dealing with a cooling problem. The modern vertical water-tube condenser, with its high gas and water velocities, is a most efficient unit, compact and economical, and its development has been the subject of a number of papers in recent years.

When proposals for a tube condenser are being considered the number and length of tubes and the number and size of passes will be obtained from a knowledge of the heat to be dissipated, the quantity and temperature of cooling water available, the appropriate heat transfer coefficients, and the economical use of power. The heat load, which is the basic quantity upon which the whole design depends, will be more accurately known if actual determinations are made at the point where the condenser is to be installed, thus avoiding assumptions which may lead to unnecessary capital expenditure or, on the other hand, inability to obtain the required degree of cooling. Again, if the performance of a condenser becomes unsatisfactory and is investigated, the heat input must be known before a correct evaluation of the test data can be made. The freezing method described in this paper is extremely useful for this purpose.

While it is true that the main function of the condensers is to cool the gas, other important physical changes occur simultaneously, several constituents of the gas phase condens-

(1) L. Silver, Trans. I.Chem.E., 1947, 25, 30.

(2) A. A. Woodcock, *Gas World*, November 26, 1949.

ing, some inorganic compounds dissolving in the water to form ammoniacal liquor while a number of hydrocarbon vapours separate as a tarry or oily layer. The condensation of the tars and the water is assisted by the presence of nuclei such as particles of free carbon, and as cooling proceeds the droplets progressively increase in size. The larger the droplets the easier they are to remove subsequently and the condensers have, therefore, a definite influence on the problem of tar fog and its elimination. The effect of the type of condenser employed has been observed by Badger[3], who found that when a high-speed exhauster which had been tested at one works was moved to another the tar fog remaining in the gas at the second works, under the same conditions of exhauster speed and gas temperature, was lower than at the first. At the first works the condensers were of the water-tube type, whereas at the second they were of the atmospheric type. Tests which have since been made with the new method of water determination provide a reason for this different behaviour. These tests, included in Table III, were made at the inlet and outlet of atmospheric condensers, with somewhat surprising results.

TABLE III.

Heat and Water Content of Gas at Inlet and Outlet of Atmospheric Condensers.

	Position	Gas temperature °F.	Water content lb./1,000 cu.ft. at S.T.P.	Percentage saturation	Heat content B.Th.U./ cu.ft. at S.T.P.
Woodall-Duckham continuous vertical retorts ...	Inlet	156	15.8	81	20.3
	Inlet	157	15.8	79	20.3
Bank A	Row I, 70 ft. from inlet	146	12.5	89	
Bank B	Row 4-5	93	3.5	134	
		126	8.0	109	
	Outlet	69	1.99	166	
	Outlet	52	1.12	173	
Glover-West continuous vertical retorts	Inlet	160	14.1	64	18.2
	Inlet	169	16.7	54	21.2
	Outlet	64	1.31	131	
	Outlet	66	1.2	114	
	Outlet	84	2.47	127	
	Inlet	160	19.4	88	24.5
	Outlet	81	2.15	119	
Horizontal retorts with scrubber standpipes ...	Inlet	171	34.0	100	41.2
	Outlet	100	3.61	113	

To enable a clearer picture to be obtained, the table includes values for the 'percentage saturation' or the ratio of the actual water content to that required to just saturate the gas, analogous to 'relative humidity' for air. Referring particularly to vertical gas which reaches the condensers in a more or less unsaturated condition it will be seen that the gas is supersaturated when it leaves the condensers. This result was at first unexpected, but when confirmed the tar fog tests were remembered and it was realised that here was the explanation. It has also been found that tar fog estimated by the impinger method at the outlet of atmospheric condensers is accompanied by water considerably in excess of the amount present in just saturated gas. Undoubtedly the tar droplets become loaded with an envelope of water and on account of their increased size are more efficiently removed by the exhausters, especially those operating at high speed. Tar fog, estimated at the outlet of the exhausters, however, is usually dry, the water carried by the droplets having been evaporated by the rise in temperature in the exhauster, but if the gas passes through secondary condensers the tar droplets act as nuclei for the condensation of more tar and also acquire a second skin of water. Thus the droplets too small to be removed by the exhausters are increased in size and their removal by, for example, Livesey washers becomes more efficient.

The apparently supersaturated condition of the gas found on the outlet of atmospheric condensers is thus due to water carried in suspension on tar droplets, and the point of interest is that this condition is not observed at the outlet of water-tube condensers. Investigations on this type are not yet complete, but the indications are that if the gas is just saturated or only partly saturated at the inlet it remains so as it passes through the condenser. It is probable that in the narrow tubes used in these condensers, where no part of the gas stream is at a distance much greater than 1 in. from the cooling surfaces, condensation of water vapour proceeds at the same rate as the removal of sensible heat, and the relative saturation of the gas is maintained throughout the condenser. In the 12 in. pipes common to atmospheric condensers, however, where cooling by radiation occurs to a relatively greater extent, a water fog is more likely to be found. As the rate of loss of sensible heat will be increased by radiation from fog particles once they are formed, more fog should then be produced. That this does, in fact, happen has been demonstrated by determinations of water vapour in the gas at the inlet, outlet and intermediate points of an atmospheric condenser. These results are included in Table III and show a progressive increase in "percentage saturation" from 80% at the inlet to 170% at the outlet.

6. Subsequent Effects of Water Vapour

The water vapour in the gas has no effect on the removal of ammonia after the exhausters, but its importance in the process of oxide purification has now been recognised as a result of the investigation[4] of the causes of hardening of oxide. The oxidising reaction requires the presence of water and to maintain the activity of the oxide it is essential to keep a film of moisture on it. Unfortunately this condition is not easily obtained in practice and the manner in which moisture may be controlled is now being studied by the Gas Research Board.

The presence of water vapour is, perhaps, most obvious when it deposits in the district mains, except, of course, where gas drying has been adopted. The introduction of gas dehydration has eliminated many of the troubles experienced on the district, but may sometimes lead to stoppages due to deposition of gum. It is now well known that the formation of gum begins in the holder where a period of storage allows time for the nitric oxide to react and, what is more important, time for the gum to settle. This settlement is assisted, as in the case of tar fog, by the loading of particles by condensed water or by the condensation of gum on a nucleus of water, so that gum is more effectively removed when the gas is stored in a wet holder and the addition of live steam at the holder inlet has been used in hot weather to increase the probability of condensation. Thus the water vapour again performs a useful function and its final reduction in the dehydration plant should be undertaken after storage in the holders.

In conclusion, I should like to thank the North Thames Gas Board for permission to publish this paper, and particularly Mr. L. Silver, for his encouragement and criticism, and Mr. E. Reid for assistance in the experimental work.

APPENDIX

The Determination of Water in Crude Gas.

The apparatus used in this method is illustrated in Fig. 2. The sampling tube may be of hard glass tubing, 5 mm. bore, or preferably of $\frac{1}{8}$ in. brass tubing which is more robust. For the brass tubing a petrol cock makes a suitable tap and being provided with a union is easier to handle, but if the test is to be carried out on the vacuum side of the exhauster a tap is not essential. The tube ends in a T-piece of 9 mm. bore fixed at an angle of about 60°, the longer limb of which is coned to fit a B.14 standard socket for connection to the first freezing vessel, the other limb, kept as short as possible, being used for the insertion of a thermometer.

The sampling tube is heated by means of three parallel circuits each consisting of 7 ft. of 22 gauge enamelled nichrome wire. One length of wire is wound on to the lower end of the tube, which should be sufficiently long to penetrate one third of the distance across the main to be sampled, the second length is wound on to the portion, about 13 in. long, between the tap and the T-piece, while the third length covers the T-

(3) L. Silver, Trans.I.Chem.E., 1947, **25**, 42 (Discussion).

(4) F. J. Dent and L. A. Moignard, 'The Hardening of Oxide in Purifiers,' Second Report, G.R.B.52.

piece and the B.14 socket attached to the first freezing vessel, being broken at the joint to enable this to be disconnected. The windings, secured in place by adhesive tape, are designed to give a maximum current of 3 amp. when connected in

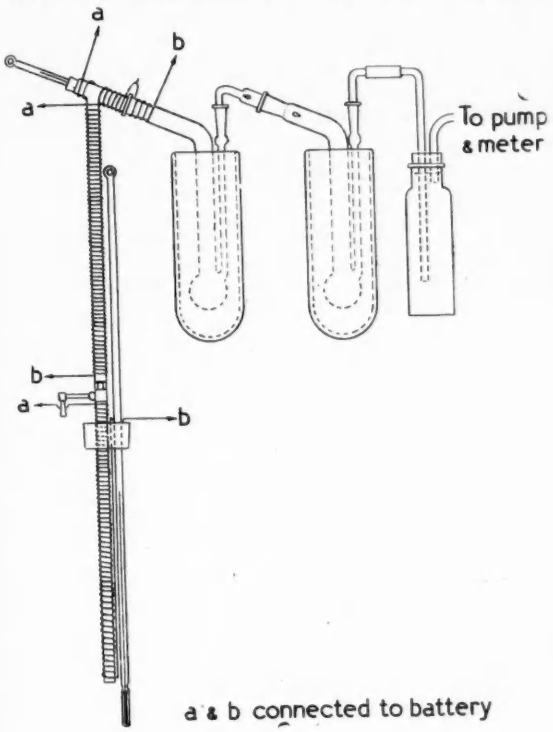


Fig. 2.

parallel to a 6 volt car battery and heating is controlled by means of a 25 ohm variable resistance and an ammeter included in the circuit. These may be conveniently fixed to a box which carries an S.U. petrol pump, operated by the same battery and used to aspirate gas through the apparatus.

A rubber bung is fitted on the lower portion of the tube and a thermometer is passed through a second hole in the bung. This thermometer should preferably be calibrated in single degrees, with an open scale capable of being estimated to 1/10th degree and reading up to say 220°F. The portion of the stem immersed in the main need not be calibrated. The bulb should be adjacent to the open end of the tube to register the correct temperature of the gas being sampled.

The Pyrex vessels in which the water is condensed are contained in Pyrex Dewar flasks 60 mm. in diameter and 200 mm. deep, supported in a light wooden stand. The main dimensions of these vessels are given in Fig. 3.

These vessels are followed by a wash-bottle containing a solution of cadmium sulphate for the removal of the remainder of the hydrogen sulphide and an acid wash to remove ammonia. The last bottle is connected to the pump and meter. A wet meter of the Hyde type with a capacity of 1/50th cu.ft. per revolution is most suitable.

To carry out a test the sampling tube is inserted in the main either in a vertical or horizontal position and is connected to the first vessel. The heating circuits are connected to the battery and the tube is allowed to warm up while the rest of the apparatus is connected. All standard joints should be greased and kept together with springs but the brass cone should not be made tight until the joint has reached the required temperature otherwise the glass socket may be cracked. When the vessels have been placed in a suitable position the freezing mixture may be put in the Dewar flasks, adding crushed solid carbon dioxide and acetone alternately to produce a slush. A thermometer inserted in the T-piece of the sampling tube with its bulb located in the standard joint ensures that the temperature of the gas passing to the vessels is maintained above that indicated by the thermometer in the main and when a difference of about 10° is obtained the test may be started. The sampling rate should not exceed 0.2 to 0.3 cu.ft. per hour the volume of gas sampled being related to its probable water content so that the quantity of water collected will be not more than 1 cc. Thus if the temperature is 150°F. and the gas is assumed to be saturated it will carry 16 lb. of water per 1,000 cu.ft., or just over 7 cc. per cu.ft., and only 0.1 cu.ft. need be sampled. The gas temperature should be recorded at short intervals, say every 2 min.

The volume of gas recorded by the meter corrected to S.T.P. will not be the true volume of crude gas sampled owing to the removal in the freezing vessels and wash-bottles of some CO_2 and all of the H_2S and NH_3. These quantities may be determined in the wash-bottles and in the final distillate but for convenience and with little loss of accuracy the following standard correction may be used.

Correction to be added to metered volume

	Horizontal Gas %	Vertical Gas %
CO_2	0.6	0.4
NH_3	1.1	0.7
H_2S	1.0	1.0
C_6H_6, &c.	1.0	1.0
	3.7	3.1

At the end of the test the vessels are disconnected and the open ends stoppered. In the laboratory they are removed from the freezing mixture and attached to the condenser and receiver (Fig. 3). The receiver is provided with a length of capillary tubing having a small bulb of approximately 2 cc. capacity and ending with a tap. Two marks spaced about ¾ in. apart are etched on the portion immediately above the bulb. The capillary is filled with dry mercury to a point just

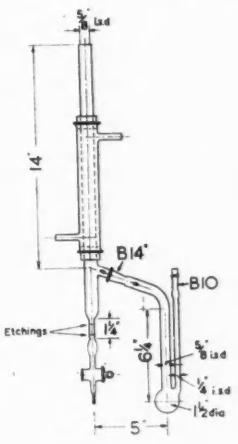


Fig. 3.

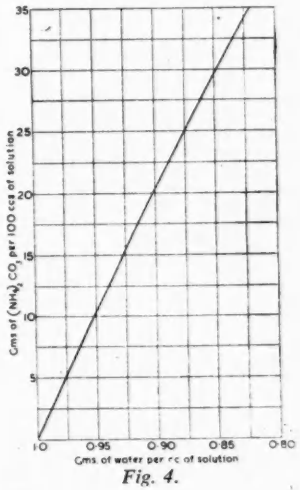


Fig. 4.

above the upper mark and dry benzene is then added to the receiver and allowed to overflow into the attached vessel until its bulb is nearly half full. Distillation is commenced, gently at first and then more vigorously until the last traces of water have passed into the receiver. It is advisable to treat the inner surfaces of the receiver and condenser with a silicone, such as Teddol, which is water-repellant, to overcome the difficulty caused by the hold-up of droplets. The method of treatment is described by K. A. Murdock[5].

The distillate is a solution of ammonium salts, mainly ammonium carbonate, and the quantity of water actually

(5) K. A. Murdock, Chem. & Ind. 1946, 366, 399.

present in the solution may be determined by analysis. It has been found to be sufficiently accurate to assume that all the ammonia is present as carbonate. The volume of this solution is measured by allowing mercury to escape from the tap until the lower surface of the solution coincides with one of the marks on the capillary. A tared weighing bottle is placed under the tap and mercury again run out until the upper surface of the solution coincides with the same mark.

TABLE IV.

Weight of Water Present in Solutions of $(NH_4)_2CO_3$.

Weight of solid in solution gm./100 cc.	Weight of water in solution gm./cc.
1.00	0.995
2.01	0.990
4.05	0.980
6.12	0.970
8.21	0.960
10.34	0.949
12.48	0.939
14.66	0.928
16.86	0.917
19.09	0.906
21.35	0.894
23.63	0.882
25.94	0.870
28.27	0.858
30.63	0.845
33.02	0.832
39.05	0.798
45.18	0.762
51.38	0.724

The bottle and mercury are weighed and the equivalent volume of solution obtained from the density of mercury at the temperature of measurement. The remainder of the mercury, the solution and the benzene are run into a flask and the contents titrated with standard acid so that the salt concentration may be calculated as gms. $(NH_4)_2CO_3$ per 100 cc. solution. The weight of water present is then obtained from the graph (Fig. 4) constructed from the values included in Table IV. An addition of 0.01 gm. should be made to the weight so found, to correct for the solubility of water in benzene, and the final result expressed in lbs. of water per 1,000 cu.ft. at S.T.P. to compare with the values for saturated gas in Fig. I.

DISCUSSION

The **President,** Mr. A. H. Savill, in thanking the author for an excellent paper, wondered whether the term 'condenser' might not be changed to 'cooler.' Gas cooler was an expression which was widely used in coke oven practice, which gave a clearer picture of the particular process. Mr. Craddock has mentioned that the serpentine atmospheric condenser was cooled by water sprays. Did it not in that case cease to be an atmospheric condenser and become a water condenser? Reference had also been made to the fact that the atmospheric condenser was now being largely replaced by the water tube condenser. He (Mr. Savill) understood that there was a tendency in some quarters to swing back to the atmospheric condenser. He would like to ask what advantages accrued when a change to atmospheric or semi-atmospheric condensers was made.

Dr. **A. E. Haffner** (North Thames Gas Board) said that if water vapour were as easily measurable as carbon dioxide there would be a greater awareness of it; when, therefore, an analysis of crude coal was considered, it should be remembered that the gaseous constituents were only half or even a quarter of the story. Figure 1 in the paper, with its information about the heat and water contents at different saturation temperatures, would facilitate a clarification of ideas. Lack of appreciation of the different heat contents of different gases had led to over-abundant capacity of condensers, outstripping of cooling water availability, &c.

In the survey of the sources of water vapour the oxygen in the coal had been used to calculate the water vapour formed, but some of the CO_2 and CO formed might have been derived from waste gas, or the products of its interaction with hot coke or from air in-leakage with partial combustion.

He suggested that the object of introducing steam into vertical retorts was not for either of the two reasons given—to control calorific value and recover heat from coke. It was to keep the extractor cool enough to operate. In so doing, a degree of calorific value control was possible, and recovery of sensible heat from the coke did occur.

The quick quenching of gas by intimate contact of liquor spray with the hot crude gas whereby adiabatic cooling occurs was a phenomenon of the greatest importance. It ensured that fractional condensation was minimised and that the deposits remained fluid. It was the aim of all modern retort design to introduce the spray as early as possible, and the shape of the offtake and position of the spray were carefully studied so that the spray just missed flowing down the retort. The scrubber standpipe in horizontal retort installation aimed at the same effect, and the coke oven industry would not exist if it did not exploit early spraying of the crude gas.

Pre-heating Boiler Feed Water

Table II in the paper showed that the heat content in the gases amounted to 61.9 B.Th.U. per cu.ft., or 7.2 therms per ton in one extreme case, or 141.4 B.Th.U. per cu.ft. approximately 2.4 per ton, in the other extreme. The former figure amounted to about one-fifth of the heat supplied as producer fuel. Counter current flow as in continuous vertical retorts led to some heat recovery by the descending coal from the rising crude gas, especially if the conditions were favourable to good flow distribution and heat transfer as in nut coal. Where tar was absent from hot crude gas, it was possible to generate steam from it as in blue water gas plants or those producers which included the equivalent of a tubular waste heat boiler in their generator boiler. Where the presence of tar prevented the use of waste heat boilers, the only form of heat recovery practised was that of using the first stage of the condensers as a means of pre-heating boiler feed water.

The washbox on carburetted water gas plant was important. Cooling by passing through a washbox caused the gas to cool, water to be evaporated, and the net result was that the hot gas velocity was almost halved and the hot gas density increased, but the back pressure was reduced to about three-quarters. It was therefore profitable to introduce spraying before the washbox if possible.

Mr. **Craddock** said that Dr. Haffner, in referring to hot carburetted water gas, had suggested that by cooling the gas as early as possible the resistance to flow was reduced, but he (Mr. Craddock) wondered whether this assumption was correct, since his own calculations indicated that the pressure loss for the hot gas entering the washbox to be only very slightly different from that for gas at 180° F. saturated.

Mr. **A. J. S. Wiseman** (North Thames Gas Board) said that the value of making the difficult determinations of the water vapour content of hot crude gas was clearly shown in the surprising information that they revealed, and in the clear understanding that had resulted of the mechanism of the process under investigation. The figures quoted in Table II formed a valuable record which he was sure would be widely used in the future.

The question of the high speed exhauster whose efficiency as a tar fog remover was increased on moving it from one works to another was an old one, and the author was to be congratulated on the complete and convincing explanation of this phenomenon.

Steam Decomposition

He would like to question the author about the figures quoted for water gas in Table II. The technique described in the appendix was hardly applicable to instantaneous determinations. The percentage decomposition of steam varied very rapidly throughout the cycle, and on down run plants, might approach nil during the slow changeover movements when steam by-passed the fuel bed. The temperature at outlet washbox had been observed also to vary continuously and to approach 212° F. during the changeover periods. He imagined that the figures quoted were average values for the whole of the gas making run.

He wished to criticise the determination of the moisture produced by the primary decomposition of the coal. A complete ultimate analysis of a coal was a lengthy matter. The oxygen content was determined usually by difference and bore all the errors of the other determinations. The possibility that the gas analysis was modified by in-leakage of combustion gases and/or air could not be excluded.

The determination of the virgin liquor yield could be carried out in duplicate in a working day using a 1/1,000 ton assay plant. Results from this plant continuously yielded values for gas, coke tar, and liquor yields, which, when summed on a weight basis, approached within plus or minus 20 lb. of 2,240 lb. per ton of coal used. If the whole of the maximum error were assigned to the liquor it would generally amount to less than 10% of the value quoted which, he submitted, would be at least as accurate as values obtained by the method given in the paper.

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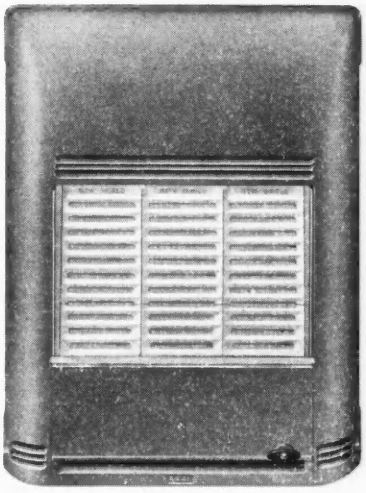

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2A

The down grading of the sensible heat in crude gas, without reduction in the total present, brought about by the use of water sprays, had many advantages, as the author had shown. It was to be deprecated, however, on the grounds that the thermal gradient was reduced and the ultimate removal of the heat rendered more difficult.

Mr. **Craddock** said that the figures quoted in Table II for water vapour in carburetted water gas were obtained by sampling the gas intermittently during the gas-making period only, the test being stopped before the steam purge commenced at the end of each 'run.' The gas temperature at the outlet of the washbox remained fairly steady during the 'run,' varying by a few degrees only, but when the purge began it naturally rose and momentarily approached the temperature of the steam.

He agreed that a number of points affecting the water vapour derived from the oxygen in the coal had been omitted, and as the oxygen content was seldom determined this source was mainly of theoretical interest. Results obtained from an assay plant would be a guide to the amount to be expected.

The down grading of sensible heat did not make its ultimate removal more difficult for the reason that the sensible heat coefficient was small compared with that for the mass transfer of water vapour.

Tar Fog Content

Mr. **E. H. M. Badger** (North Thames Gas Board) said that, as Mr. Craddock had mentioned, the fact that a high speed turbo-exhauster was moved from one works to another made it possible to observe the effect of the type of condenser on the tar fog content of carburetted water gas. Under comparable conditions of exhauster speed and temperature the tar fog content of the gas leaving the exhauster was 70 gr./100 cu.ft. with water-tube condensers and 40 gr./100 cu.ft. with atmospheric condensers. It had been shown in a series of tests on the stream with water-tube condensers that the tar fog leaving the exhauster depended not only on the speed of the exhauster, but also on the temperature of the gas leaving the condenser. (Badger & Wilson, J.S.C.I., 1946, 65, 119, 121.) It was probable that the more the gas was cooled, the bigger was the average size of the drops and that the exhauster removed all drops above a certain critical size which depended on the peripheral speed of the exhauster. If a water fog was formed in the condensers, it was likely that the water would use a tar fog droplet as a nucleus and that a bigger particle would be formed. Hence the amount of tar fog leaving the exhauster would be less when the gas was cooled in atmospheric condensers than when it was cooled in water-tube condensers.

It was possible to observe under the microscope that the tar drops were sometimes enclosed by an envelope of water. The drops could be deposited in a suitable manner by means of the thermal precipitator, an instrument which ingeniously used the repulsion of small particles from a hot surface to a cold one.

The gas was passed through a slot formed by two microscope cover glases, between which was a heated wire. The particles were repelled from the wire to the coverslips and the deposit could be examined under the microscope. When the gas examined was that from a coal gas stream, the tar drops could be seen to contain a black nucleus of free carbon. The tar from carburetted water-gas, on the other hand, did not show this black nucleus, but sometimes a white nucleus was seen. This was possibly silica due to the decomposition of silico-methane.

There was evidence that a water mist could be formed in the secondary condensers in a coal gas stream even when these were the water-tube type. In a stream from intermittent vertical chambers, the concentration of tar fog leaving the secondary condensers was greater than at the inlet and in the impingement apparatus used for determining the tar fog, water was always precipitated as well as tar, even though the whole apparatus was carefully thermostated to the temperature of the gas in the main. The wet tar fog leaving the secondary condensers was always very efficiently removed by the Livesey washers, only about 2 gr./100 cu.ft. passing to the purifiers. But when the secondary condensers were by-passed, the tar entering and leaving the Livesey washers was dry and the amount leaving went up to 9 gr./100 cu.ft. It would seem that the lack of condensation of water vapour meant that a smaller particle entered the Livesey washers so that less was removed.

The question of the size of particle formed by condensation from a super-saturated vapour was very interesting. Some light on the mechanism of condensation was afforded by a study of the formation of gum particles in coal gas. As was well known, gum was formed by the reaction of small amounts of nitric oxide with unsaturated hydrocarbons. When gas containing nitric oxide was streamed through a 10 cu.ft. gasholder a cloud of very small particles was first formed. The particle concentration was very high—about 200,000 per c.c. When more gas was passed through the holder the particle count rapidly dropped because not only were the particles being swept out, but there was also loss by coagulation and settlement. Observations showed that those particles that remained in the holder were growing in size and that for a period of an hour or more all the gum vapour was condensing on particles already present, no new ones being formed. After a while the particle count dropped to below 1,000 per c.c. At this stage the particle count suddenly went up to about 3,000 per c.c., and it could be observed from the deposits in the thermal precipitator that a new batch of small particles had been formed. These in turn were shown to grow larger until the particle concentration dropped to below 1,000 per c.c. whereupon a new batch of particles again appeared. This periodic rise and fall in the particle concentration apparently continued as long as gas was streamed through the holder. The explanation offered was that initially the concentration of vapour was sufficient to permit the formation of particles without the aid of a nucleus, this process being known as 'spontaneous condensation.' After this the vapour concentration was reduced by diffusion to the particles already present until so few particles were left that the vapour concentration started to rise again. It then reached a value high enough to permit of condensation on to gaseous ions, but as soon as these new particles formed the vapour concentration fell once more by diffusion to the particles.

It was possible that the same sort of phenomenon might be observed in the condensation of tar vapours. For ease of removal of fog by mechanical means it was best to have relatively few large particles rather than a large number of small particles. It was conceivable that it would be possible to avoid the formation of new drops of tar fog by 'seeding' the gas at the inlet of condensers with the right concentration of drops formed by prior condensation of a small portion of the gas.

Maximum Use of Available Water

Mr. **E. A. J. Patrick** (North Thames Gas Board) said that although in the present instance the removal of tar fog was not a primary reason for the existence of cooler or exhauster, he was at one time associated with some work in which the removal of particles—dust particles in this case—from a gas stream by condensation upon them, was the primary object.

The conditions were almost exactly parallel, in that there was a stream of producer gas with a predetermined temperature, and into which, therefore, only a fixed amount of water could be evaporated, and the problem resolved itself into making the maximum use of this available water.

Any means of particle removal entailed a threshold size above which the particle could be removed, and it was clear that any considerable increase in particle size above this threshold was wasteful of water. The point that he wished to emphasise was that under steady conditions the rate of increase of surface area of the particle is constant, which meant that the larger the particle became, the more rapidly did it take up water at the expense of the smaller particles. It would also be shown that as the surface area increased, the increase in settling velocity, or in the case of centrifugal action, the radial acceleration, became progressively more expensive in water.

It followed from this that each particle should be removed as soon as it reached the threshold size, to prevent it from imbibing water required by other particles. The work to which he referred, although it had come to a premature end owing to war conditions, had indicated that it was definitely an advantage to have alternate stages of partial condensation and passage through the dust removal device, so that particles large enough to be removed were unable to take up more water.

He would not suggest that it was worthwhile doing this under normal circumstances, but if ever tar fog removal became of primary concern, such a procedure would have advantages.

Mr. **Craddock** replied that in the primary cooling of coal gas there was ample water vapour available for the growth of tar particles, and these were constantly being removed on the pipe walls of the condenser. The effect of an additional stage of cooling, to which Mr. Patrick referred, was shown in cases where secondary condensers were employed, some of the smaller particles of tar fog which survived the exhauster being loaded by further condensation so that they were more effectively removed by subsequent tar precipitators.

Mr. **E. C. J. Reid** (North Thames Gas Board) said that recent tests on efficiencies of scrubbers cooling gas from rotary grate producers had necessitated a knowledge of the heat content of the hot gas. Tests made by the experimental technique described in the paper gave a value of 4.9 lb. of water per 1,000 cu.ft., equivalent to a heat content of 19.1 B.Th.U. per cu.ft. The value obtained by a heat balance across the scrubber was 19.7 B.Th.U. per cu.ft. It was interesting to note that calculated on a volume basis the water content was 9.3% ; this figure could be compared with a value of 9% given by Dr. Paxton in his paper, 'Fuel Requirements of Carbonising Plant.'

Mr. Craddock had drawn attention to the trebling of the heat load on condensers which occurred after installing scrubber standpipes in horizontal retort houses. It was fortunate that this older type of carbonising plant was usually provided with atmospheric condensers, for it was this type of condenser which could have its cooling capacity greatly extended by the provision of an adequate water supply. The water need not be particularly clean or cold, and could be recirculated without cooling. It was, however, important that the water should be evenly distributed over all the pipes, and in this connection attention should be paid to the publications of Mr. Silver and Mr. Woodcock referred to in the paper.

Mr. **F. Broomhead** (W. C. Holmes & Co., Ltd.) remarked that Fig. 1 and Table I in the paper brought out a point which was not always fully appreciated by gas engineers—the rapid increase in the total heat content of saturated gas with a rise in temperature. The wide variations in the heat content of crude gas in Table II would also make it clear that a condenser installed to handle the crude gas from horizontal retorts in times when the spraying of gas off-takes was not generally practised would no longer be capable of cooling adequately the crude gas from a similar coal throughput after the fitting of small sprays or the replacement of the horizontal retorts by steamed vertical retorts.

Low Heat Content Figures

Referring again to Table II, it appeared that the figures given for heat content of the gas from continuous vertical retorts were low. The calorific value might have been high and steaming not very heavy ; one would normally expect the heat content from such retorts to be very much higher, up to 50 B.Th.U. per cu.ft.

It was sometimes the case that a gasworks had only one liquor storage well, into which therefore all liquor from the various collecting points on the works flowed. It should be remembered that where such liquor was fed to the sprays, free ammonia would be evaporated into the gas and this might result in the ammonia washers being overloaded.

When comparing results obtained from horizontal retort carbonisation with or without scrubber standpipes or Congden pipes, there was a tendency in the former case for naphthalene deposits in condensers to be heavier and more troublesome to handle. Could Mr. Craddock confirm this, and if so, could he indicate the cause ?

Mr. **Craddock** agreed that the total heat contents of gas from continuous vertical retorts, quoted in Table II, were typical of lightly steamed retorts, and that where heavier steaming was practised the saturation temperature would be higher. With regard to the effect of scrubber standpipes on the deposition of naphthalene in the condensers, he had no information on that point.

Mr. **L. Silver** (North Thames Gas Board), in discussing the background of the paper, said that the work was undertaken as part of the general study of the distribution and disposition of the heat imparted to the gas in the carbonisation process. Their interest had been particularly arrested by the apparently high efficiency of the adiabatic cooling process. Thus, in the very restricted space of the scrubber standpipe or, on a very large output of carburetted water gas in a short downcomer main and in the washbox itself, the temperature of the hot gas was reduced from anything up to 1,000° F. down to 140-180° F. Although the sensible heat thus extracted still remained in the gas as latent heat of water vapour, consideration of the mechanism of the process made it clear that the whole of it had first been transferred by ordinary sensible heat convection into the liquid water before it could be therein converted into latent heat of evaporation and unfortunately retransferred into the gas by mass convection.

Thus, although the gas was greatly cooled in the process, the whole of that heat had subsequently to be transferred again out of the gas with much greater difficulty in the primary condenser.

It was usually assumed that the gas leaving the hydraulic main or washbox was saturated with water vapour, but the analysis he had just described made it unlikely that such a very close equilibrium could be possible with such restricted contact. They had therefore thought that some profitable information would accrue from an accurate estimate of the degree of saturation in the crude gas after adiabatic cooling ; the paper presented some of the results so far attained. It was clear that in general saturation was not reached. It was hoped that they would be able to apply a modified technique to the analysis of the instantaneous condition of the gas leaving the washbox of a water gas set, which was the problem which they initially set themselves but in which they found the difficulties so great that they had first to work out methods on continuous streams.

One of the most interesting phenomena indicated by the investigation was the progressive increase in the degree of saturation of the cooling gas as it passed along the tubes of the atmospheric condenser. The gas might enter in a highly unsaturated condition and, through losing sensible heat at a higher rate than the vapour, was transferred to the cold walls, might become saturated part way along and, from there on, water condensed in the body of the gas causing fog in addition to the condensation which went on on the cooling walls of the pipes. This did not appear to occur in water tube condensers where the degree of saturation appeared to remain almost constant as the gas cooled.

This difference of behaviour appeared to be connected with the larger cross-section of the condenser tubes. In the relatively narrow spaces between the tubes of the water tube condenser the transfer of sensible heat due to the temperature differences between the gas and cooled wall kept pace with the mass transfer of water vapour due to the partial pressure of the cooled water on the wall surface. In the wider tubes of the atmospheric the same proportionate cooling and vapour transfer occurred, but the sensible heat loss was appreciably increased by radiation from the larger body of hot gas to the cold walls and from the tar fog and dust particles contained therein. This radiation was hardly affected by the distance from the walls so that all parts of the gas were cooled thereby. The sensible heat loss was thus occurring throughout the gas at an enhanced rate no longer in step with the loss of water vapour to the walls so that saturation increased and fogging occurred, leading to a greatly increased radiation loss and more fogging.

Moisture in Coal

Mr. **L. J. Clark** (North Thames Gas Board) said that in the paper moisture in coal was listed among the sources of water vapour. It appeared likely that with the changes in the coal industry, including dust suppression, the washing of coal would soon be fully employed. The gas industry would then be asked to handle washed small coals. In these the moisture content might vary with the technique of washing employed. If the washing plant were equipped with centrifuges, water content might be from 6% to 7% ; if not, water content might rise to 9% or 10%. If this occurred, 9% to 10% of the water would come away with the gas and it would then comprise 30% to 40% of the weight of the gas. The heat load on the cooling apparatus would be appreciably increased thereby, and the quantity of water vapour in the gas would be nearly doubled.

Mr. **F. O. Hawes** (Eastern Gas Board), in a written contribution, said Mr. Craddock's paper once again brought to notice the extreme importance of the water vapour content of gas as it left the retort house. To the other points that he had mentioned, he might have added the profound effect it had upon the strength of ammoniacal liquor which may be made.

He (Mr. Hawes) had long been satisfied that the gas was not completely saturated with water vapour at the sprays for the reason that he had shown it still to be slightly unsaturated at the inlet to the condensers after passing through several feet of foul main.

In contrast to Mr. Craddock's micro-technique, his own method had been to obtain the heat balance over the water-cooled condensers, using weekly average figures of hourly readings of temperatures. The gas volumes were measured hourly and the water consumption was recorded. Frequent measurements were made of the quantity and temperature of the condensate neglecting the small heat loss from the surface of the condenser. The heat lost from the gas must be gained by the water and the condensate.

These weekly figures were worked out over a period of years for a setting of intermittent vertical retorts with the following results. The inlet condenser temperature varied from 180° F. to 185° F., while the saturation temperature was